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Spatial Relationships, Movements, and Habitat Associations of Introduced “Non-Native” Elk Populations on Etolin and Zarembo Islands, Alaska

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SPATIAL RELATIONSHIPS, MOVEMENTS, AND HABITAT ASSOCIATIONS OF INTRODUCED “NON-NATIVE” ELK POPULATIONS ON ETOLIN AND ZAREMBO ISLANDS, ALASKA

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Abstract

Etolin and Roosevelt Elk were introduced to Afognak Island, Alaska in 1929 (State of Alaska, 2013). Due to the success of that introduction, Roosevelt Elk and Rocky Mountain Elk were subsequently introduced to Zarembo and Etolin Islands in Southeast Alaska in 1987. Due to the environment of Southeast Alaska, the ability to determine movements, trends, and habitat preferences are limited. In support of the Alaska Department of Fish and Game (ADF&G), this project analyzes the habitat preferences of the elk based upon data from global positioning systems. Locational data is analyzed for proximity to managed lands and considers proximity to fresh water and slope. Findings will be incorporated into ADF&G's long term management of the elk and the managed areas.

Acknowledgements

I would like to thank Mr. Richard Lowell of the Alaska Department of Fish and Game for his assistance and guidance through this process. I would also wish to thank Mr. Robert Davidson for his insight and patience.

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Chapter One: Introduction

Background

In 1929, elk were successfully introduced to Afognak Island, Alaska. Fifty-six years later, the Alaska State Legislature directed the Alaska Department of Fish and Game (ADF&G) to transplant elk to "suitable" locations within Alaska (State of Alaska, 2013). To meet these legal requirements, the ADF&G conducted analysis to determine potential locations for transplant and type of elk. Roosevelt elk were chosen due to the habitat similarity of Southeast Alaska and their traditional habitat of the Oregon and Washington coastal region (Alaska Department of Fish and Game, 1985).

Prior to 1987, there were six failed attempts to introduce elk to Southeast Alaska, specifically Etolin and Zarembo Islands (Alaska Department of Fish and Game Division of Wildlife Conservation, 2011). In 1987, 33 Roosevelt elk and 17 Rocky Mountain elk were moved from the Elkhorn Wildlife Management Area, Oregon to Etolin and Zarembo Islands (Lowell, R., Beier, L., & Koch, C., 2009). Rocky Mountain elk were chosen due to the limited numbers of Roosevelt elk available. The initial losses of the transplanted elk were high; however the population stabilized within 18 months of release (Lowell, R., Beier, L., & Koch, C., 2009). In 1994, the

ADF&G estimated the elk population to be 100 to 125 animals, prior to the last radio collar failing (Lowell, R., Beier, L., & Koch, C., 2009). Since 1994, additional animals have been collared with Global Positioning System (GPS) transmitting devices.

Etolin and Zarembo Islands are located in Game Management Unit 3 (GMU-3), within the ADF&G game management structure (Alaska Department of Fish and Game Division of Wildlife Conservation, 2011). The goal of GMU-3, based on the 1999 Draft Southeast Alaska Elk Management Plan, are: to manage the area for hunting opportunities, maintain elk populations on Etolin and Zarembo Islands below carrying capacity, limit the spread of elk to adjoining islands and mainland, and maintain post-harvest ratio of 25-30 bulls to 100 cows (Alaska Department of Fish and Game Division of Wildlife Conservation, 2011). In order to meet these objectives, the ADF&G needs to monitor elk activities on Etolin and Zarembo Islands. The goal of this case study is to assist the ADF&G in determining elk movements by answering the following questions:

- *Is there an elk habitat preference for managed or unmanaged land?*
- *Do the elk show a preference for specific locations based upon the season?*
- *Do the elk have a preferred calving location?*
- *Is there a preference between elk location and terrain factors, such as slope, availability to fresh water, and proximity to managed lands?*

Elk

According to the Oregon Wild (2013), Roosevelt elk bulls have an average weight between 700 and 1,100 pounds while cows average between 575 and 625 pounds. The initial losses of the transplanted elk were high most likely due to predation and environmental factors (Alaska Department of Fish and Game Division of Wildlife Conservation, 2011).

There has been numerous studies regarding habitat, feeding habits, and influences of human impact on transplanted elk (Bowyer, 1981; Schwartz, II & Mitchell, 1945; Bettinger, Boston, & Sessions, 1998; Kneib, Knauer, & Kuchenhoff, 2009; Niederleitner, 1987; Gates and Hudson, 1981; Skovlin, 1982). This proposal covers a sampling of the literature available to draw upon for study.

According to Kneib, Knauer, & Kuchenhoff (2009), one of the most crucial requirements of the conservation and management of wildlife is the understanding of the habitat in which they live in. Suitable habitat for elk requires five key components in order to survive in a specific area or region: food, vegetative cover to provide warmth, vegetative cover for security, space and an available water source (Niederleitner, 1987). Within the food component, there are specific nutritional requirements that can only be found in the taxa grasses family, forbs and shrubs (Niederleitner, 1987;

Kufeld, 1973). Kufeld (1973) identified and documented 170 specific grasses, shrubs, and forbs that elk have known to subsist on; however, elk have been known to change diets depending upon the region that they are located in due to environmental factors such as snow, rainfall, and availability for browsing (Niederleitner, 1987).

In addition to understanding the food source, thermal issues are an important consideration for elk (Niederleitner, 1987). Thermal considerations include the ability to provide warmth as well as cover for security (Niederleitner, 1987). Studies have shown that elk prefer dense timbered areas and tend to bed down at night facing south in order to ensure warmth (Niederleitner, 1987; Gates and Hudson, 1981; Skovlin, 1982). These thermal issues may be one of the reasons why elk have the tendency to return to the same wintering areas; whether there is shortage of food supply or not in that area (Schwartz, II & Mitchell, 1945). Das (1998) and Raymer (2000) suggest that the forest itself along with the timber management practices have an impact on wildlife.

Models have been developed to analyze the habitat of elk (Posillico, Meriggi, Pagnin, Lovari, & Russo, 2004; Cooper & Millspaugh, 1999; Railsback & Harvey, 2002; Bettinger, Boston & Sessions, 1998). One method is to develop habitat selection based upon grid cells (Posillico, Meriggi, Pagnin, Lovari, & Russo, 2004), while a second model uses a multinomial logit model (Cooper & Millspaugh, 1999). A third model was developed by Railsback and Harvey (2002) to predict how animals select a specific habitat is determined by food source and mortality risks. The fourth model, developed by Bettinger, Boston and Sessions (1998) developed the habitat effectiveness model (HEI) for rating potential habitat for elk based upon habitat cover, size and space of foraging. The HEI model accounts for the increased movement of the Alaska Elk's tendency to spend time feeding and moving during the sunrise and sunset periods and the decreased movement at other times of the day (Bowyer, 1981) potentially due to other habitat factors. A fifth model developed by Brown, Schreier, Thompson, and Vertinsky (1993) developed criteria based upon suitability; suitability is determined by elevation, slope, slope position, dominate species of overstory coverage, height class and crown closure class. Unlike the HEI model, the suitability model by Brown, et al (1993) does not account for the increased movement of elk. Another difference between the HEI model and the suitability model is that the HEI model considers changes in terrain (Brown, et al, 1993)

Environment

Etolin and Zarembo Islands are located in the Tongass National Forest in Southeastern Alaska. The Tongass National Forest is the largest national forest in the United States and is approximately the size of West Virginia (United States Forest Service, 2012). The Tongass National Forest is a temperate rain forest with average precipitation accumulation of 1.5 meters a year (Weather.com, 2013). The average temperatures for this region range from -4°C in the winter to 18°C in the summer months (Weather.com, 2012). The significant amount of rain and cloud cover in the region prevents long term observations of wildlife. Figure 1 depicts the study areas.

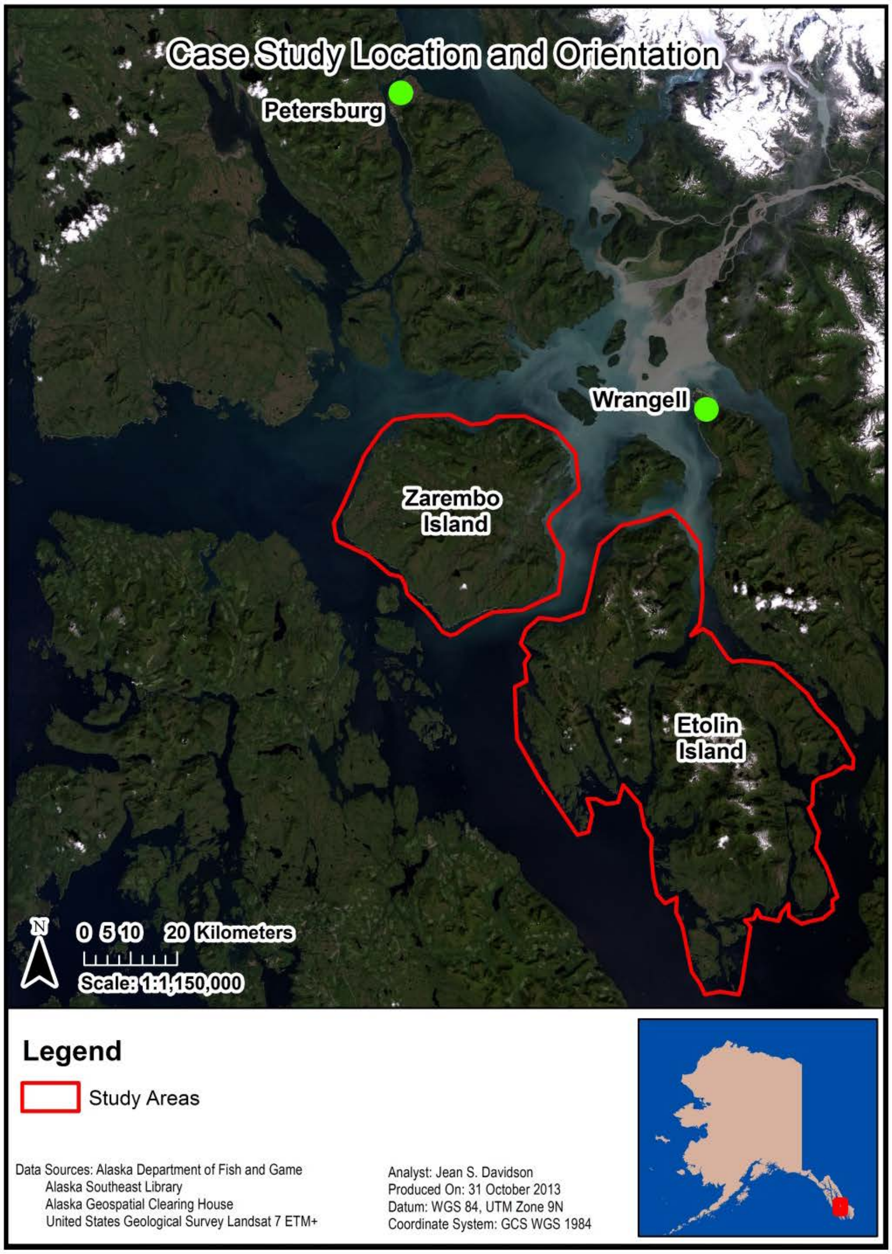

Figure 1. Case Study Location and Orientation

Etolin and Zarembo Islands consists of uneven-aged old growth forests, forested muskeg and forest scrubs (Kirchhoff, M. & Larsen, D., 1998). Western Hemlock, Sitka Spruce, Alaska Cedar, and Western Red Cedar provide overstory coverage for the elk and other wildlife (Kirchhoff, M. & Larsen, D., 1998). The underbrush provides foliage which includes: tall shrubs, low growing evergreen plants, forbs, and ferns (Kirchhoff, M. & Larsen, D., 1998). Due to the thick canopy and dense vegetation, visual observation of elk movement is limited (Alaska Department of Fish and Game Division of Wildlife Conservation, 2011).

Both Etolin and Zarembo Islands have wildlife that may be considered predatory toward the transplanted elk. Based upon fieldwork conducted by ADF&G, exact predation levels are unknown; however wolves appear to be the major predator in the area (Alaska department of Fish and Game Division of Wildlife Conservation, 2011). Brown bears, black bears and wolves have been identified on Etolin Island. In comparison, only wolves and black bears have been identified on Zarembo Island (Alaska department of Fish and Game Division of Wildlife Conservation, 2011).

Managed and Unmanaged Lands

The U.S. Forest Service developed an adaptive timber harvesting plan in 1979, which includes Etolin and Zarembo Islands (United States Forest Service, 2012). Das (1998) states that it is crucial for management plans to include non-timber and intangible aspects, i.e. wildlife, in the planning and managing of the forest. Das (1998) continues to discuss the possibility of the harvest patch size may positively impact the wildlife based upon the spatial configuration.

Both Etolin and Zarembo Islands have been harvested for timber; however the impact between the two islands is very different (Blejwas, Lowell, & Porter, 2007). Zarembo Island has an extensive road system and other basic infrastructures such as a dock and bunk house (Blejwas, Lowell, & Porter, 2007). In contrast, Etolin Island does not have a road system or any other permanent infrastructure (Blejwas, Lowell, & Porter, 2007). According to the current timber harvest plan, 30,000 acres are scheduled to be harvested on Etolin Island; which may influence the distribution of the elk (Alaska Department of Fish and Game Division of Wildlife Conservation, 2011). The ADF&G (1985) has hypothesized harvested areas of 25 years in age or less would be beneficial to elk based upon the size and energy the animal would expend in comparison to the energy usage of the snow and slash regions of Etolin and Zarembo Islands.

In order for the U.S. Forest Service to coordinate efforts of timber management on Etolin and Zarembo Islands, understanding of the elk habitat is necessary for effective management of this species (Lowell, Beier & Koch, 2012). Niederleitner (1987) found that one of the consequences of multiple resource management plans has been the coordination between the multiple agencies responsible for habitat, wildlife, and timber harvesting. According to Das (1998), a management plan based upon timber and wildlife is essential. The coordination between ADF&G and the U.S. Forest Service will assist in the long term management of the Tongass National Forest (Store & Jokimaki, 2003).

Geographic Information Systems

Geographic Information Science (GISc) provides tools (geographic information systems-GIS) and methodologies to assist management in developing strategies to resolve natural resource conflicts (Brown, Schreier, Thompson, & Vertinsky, 1993). Brown, et al (1993) employed the GIS to generate overlays, location maps, and determine the environment. The flexibility of a GIS in conjunction with simulation modeling provides an innovation methodology as well as a method to examine potential conflicts (Brown, et al, 1993). Store and Jokimaki (2003) found GIS has been used to produce complex models and data elements for analysis. In addition to producing complex models, the software has allowed new modeling techniques to be used to gain a better understanding of a species habitat (Rotenberry, Preston, & Knick, 2006). The modeling and analysis capabilities from GIS systems have allowed the ability to assess spatial patterns at the regional scale, examining elk habitat through spatial and temporal analysis (Rotenberry, Preston, & Knick, 2006; Bettinger, Boston, & Sessions, 1998; Kaufmann, 2000). The GIS provides a reliable modeling method that can predict habitat suitability (Rotenberry, Preston, & Knick, 2006).

Using a GIS, Stewart, Bowyer, Kie, and Hurley (2010) studied female mule deer and North American elk habitats using digital elevation models (DEM), habitat characteristics and the multi-response permutation procedures to examine the distribution of the elk cows based upon the winter season. A similar model was developed by Miller (2012) to examine sheep grazing patterns in Idaho. Kaufman (2000) suggests that a GIS model may allow managers to understand the complex spatial relationships between the habitat and wildlife. The GIS will provide the means to conduct habitat analysis of Etolin and Zarembo Islands.

Chapter Two: Design and Implementation

Global Positioning Systems

Between 2008 and 2011, global positioning system (GPS) enabled tracking of six elk occurred. Although this is a limited sample size, 27,000 successful locations have been geolocated on Etolin and Zarembo Islands. Sample data from 1990 radio telemetry indicated discreet herds on Etolin had developed (Blejwas, Lowell, & Porter, 2007). The data readings from the 1990 period were compared to the 2008 to 2011 periods to verify regional approximations. The GPS information obtained from the tracking collars will be invaluable as environmental factors limit the aerial observation of elk on either Etolin or Zarembo Islands. Frair, Merrill, Visscher, Fortin, Beyer, & Morales (2005), using GPS information, found the patterns of elk movement reflect spatial characteristics of forage patches within specific parameters such as size of forage patch and location of cover. In addition, Frair, Merrill, Visscher, Fortin, Beyer, & Morales (2005) were able to determine that the natural foraging habitats include wet or dry meadow along with wet meadows and cutover forests.

Analysis Methodology

Due to the specific questions requested by the ADF&G, the model developed by Brown, Schreier, Thompson, and Vertinsky (1993) was chosen.

The Brown, et al. (1993) model detailed suitability based upon elevations, slope, slope position, dominate species of overstory coverage, height class and crown closure class. Movement type and duration of the specific movement was not practical based upon the known frequency (1 to 6 hour intervals) of the GPS readings. The GPS data was reviewed for locational errors and consistency, to ensure data met minimum criteria. GPS position data points which could not be geolocated within the area of the study were removed.

Data for this case study was obtained from three primary sources: ADF&G, Southeast Alaska GIS Library and Alaska Geospatial Clearinghouse. Table 1 describes the data sets obtained from each source. Additional data sources were reviewed and analyzed, however due to the limited data availability for Southeast Alaska several data sets were discounted.

Table 1. Data Sources

Source	Data Set Applied
Alaska Department of Fish and Game	GPS Readings of Collared Elk
Alaska Geospatial Clearinghouse	Digital Elevation Models
Southeast Alaska GIS Library	Hydrology, National Land Cover, Size Density
United States Geological Survey	Landsat

Specific dates and times for analysis were critical to ensure continuity across the data. Peak rut and calving dates were based Roosevelt elk studies and analysis from Schwartz and Mitchell (1945). Due to the very northern location of Southeast Alaska, morning, afternoon, and evening time periods have little meaning. In order to accurately notate day and night locations of the elk; the civil twilight table was applied. Using a Julian calendar, the dates and times were compared to the National Oceanic and Atmospheric Administration civil twilight calendar to determine day or night locations. Seasonal dates were applied using the vernal and autumnal equinox and the winter and summer solstice. Table 2 provides a summary of the dates applied to this case study.

Table 2. Summary of Dates

Activity	Date
Peak Rut Season	15 Sept. - 1 Oct.
Peak Calving Season	15 May - 15 Jun.
Civil Twilight	1:54am to 9:58pm variation
Autumnal Equinox	22 Sept. 2008, 22 Sept. 2009, 22 Sept. 2010, 23 Sept. 2011
Winter Solstice	21 Dec. 2008, 21 Dec. 2009, 21 Dec. 2010, 21 Dec. 2011

Vernal Equinox	19 Mar. 2008, 20 Mar. 2009, 20 Mar. 2010, 20 Mar. 2011
Summer Solstice	20 Jun. 2008, 21 Jun. 2009, 21 Jun. 2010, 21 Jun. 2011

Applying GISc techniques, elk locations were analyzed for proximity to managed and unmanaged lands, water, and slope using proximity and spatial statistics analysis. These variables would be analyzed to determine local elk habitat preferences.

Chapter Three: Results

Upon analysis of the available data for Southeast Alaska, it was determined neither the model developed by Brown, et al. (1993) nor the HEI model would be supported. After discussing options with the ADF&G, it was determined to conduct geographic statistical analysis using toolsets within ArcGIS software to determine elk habitat preferences.

Etolin Island

As requested by the Alaska Department of Fish and Game, using geostatistics and analytical toolsets within ArcGIS software Table 3 thru Table 5 provide summaries of elk preferences on Etolin Island. Figure 10 through Figure 30 provides visual results of the data. These tables and figures are a summation of both the day and night habitat preferences of the elk, which was determined from a total of 63,643 georeferenced points. In order to answer the habitat preference question based upon seasonal variation, density models were developed (Figure 3 through Figure 9). Due to the number of reference records each analysis area was subsetted in order to obtain data granularity. The subset areas are depicted in Figure 2.

Figure 2. Etolin Island, Alaska Subset Areas

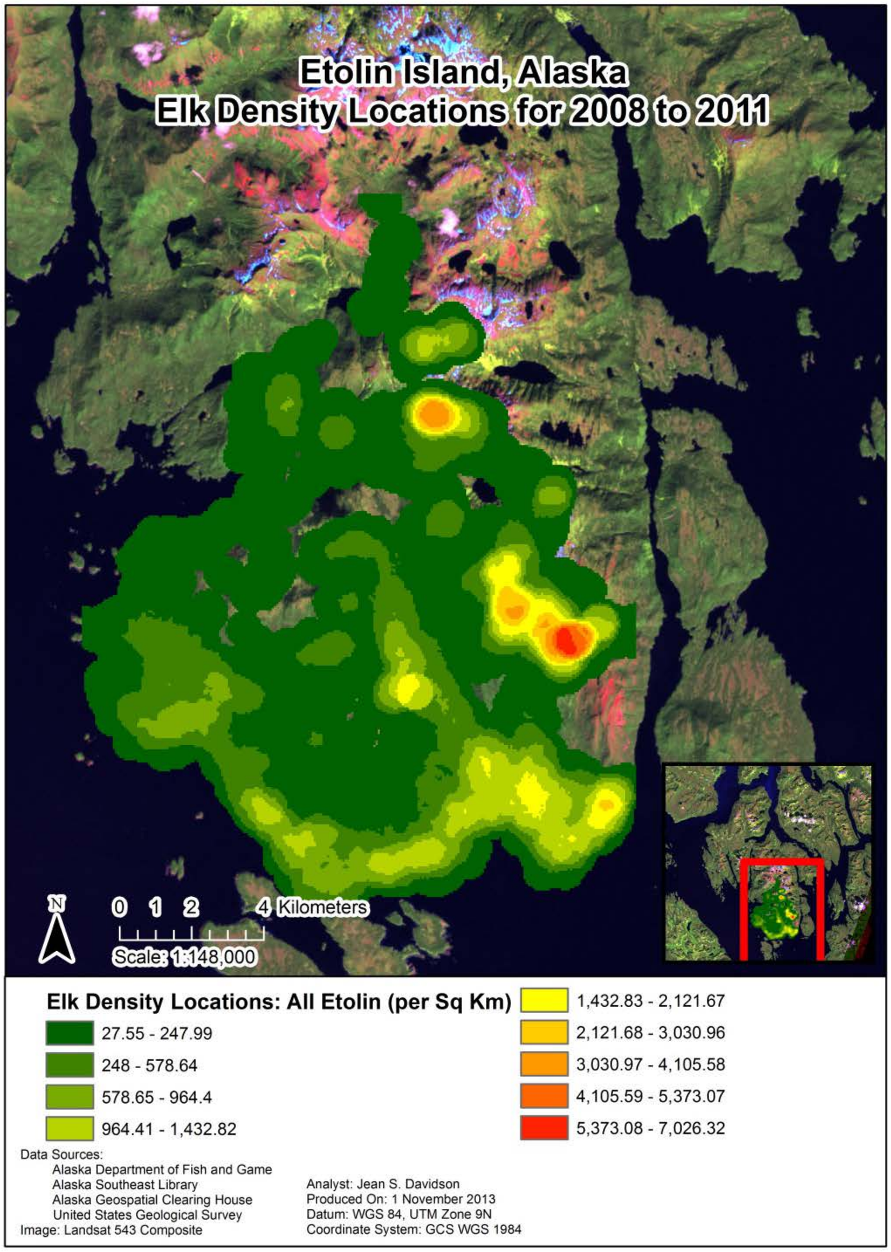

Figure 3. Etolin Island, Elk Density Locations for 2008 to 2011

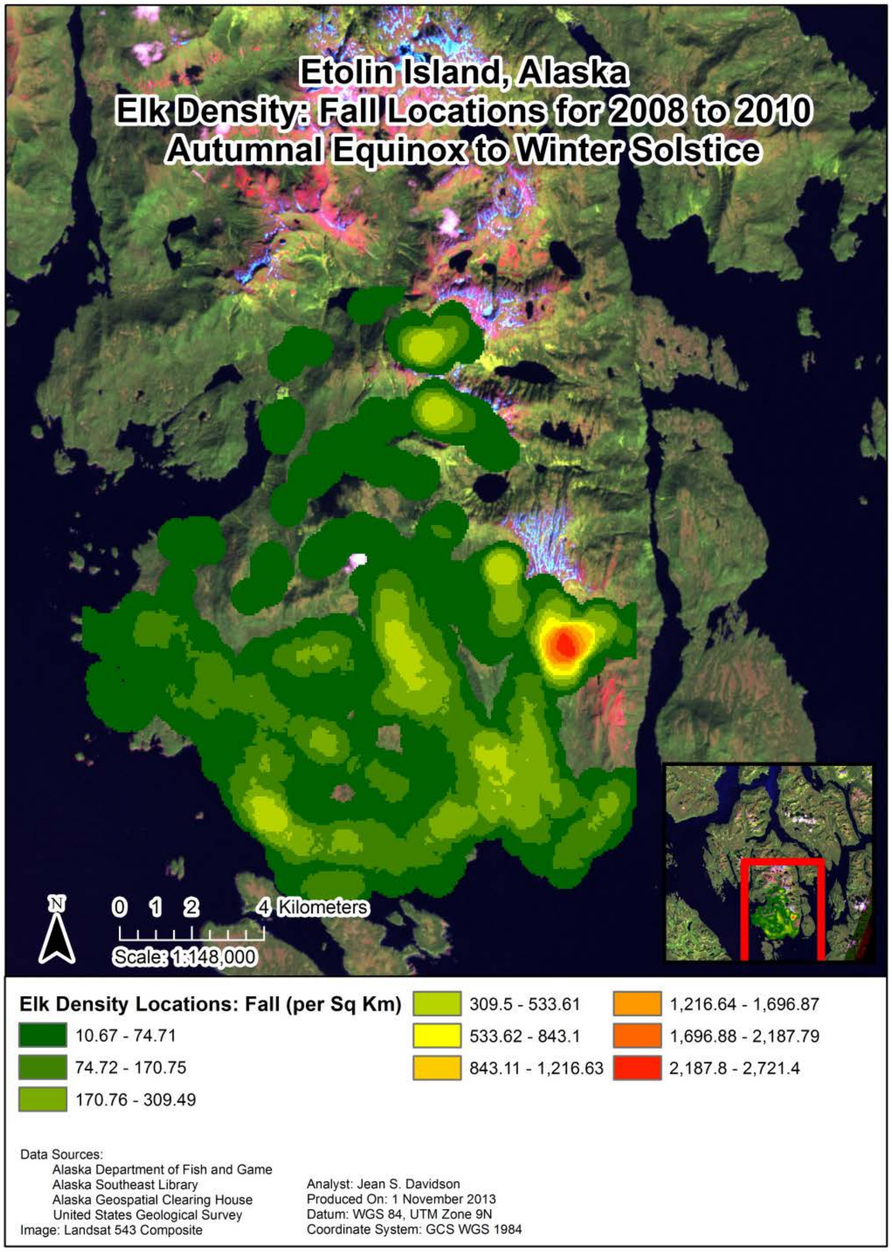

Figure 4. Etolin Island, Elk Density: Autumnal Equinox to Winter Solstice

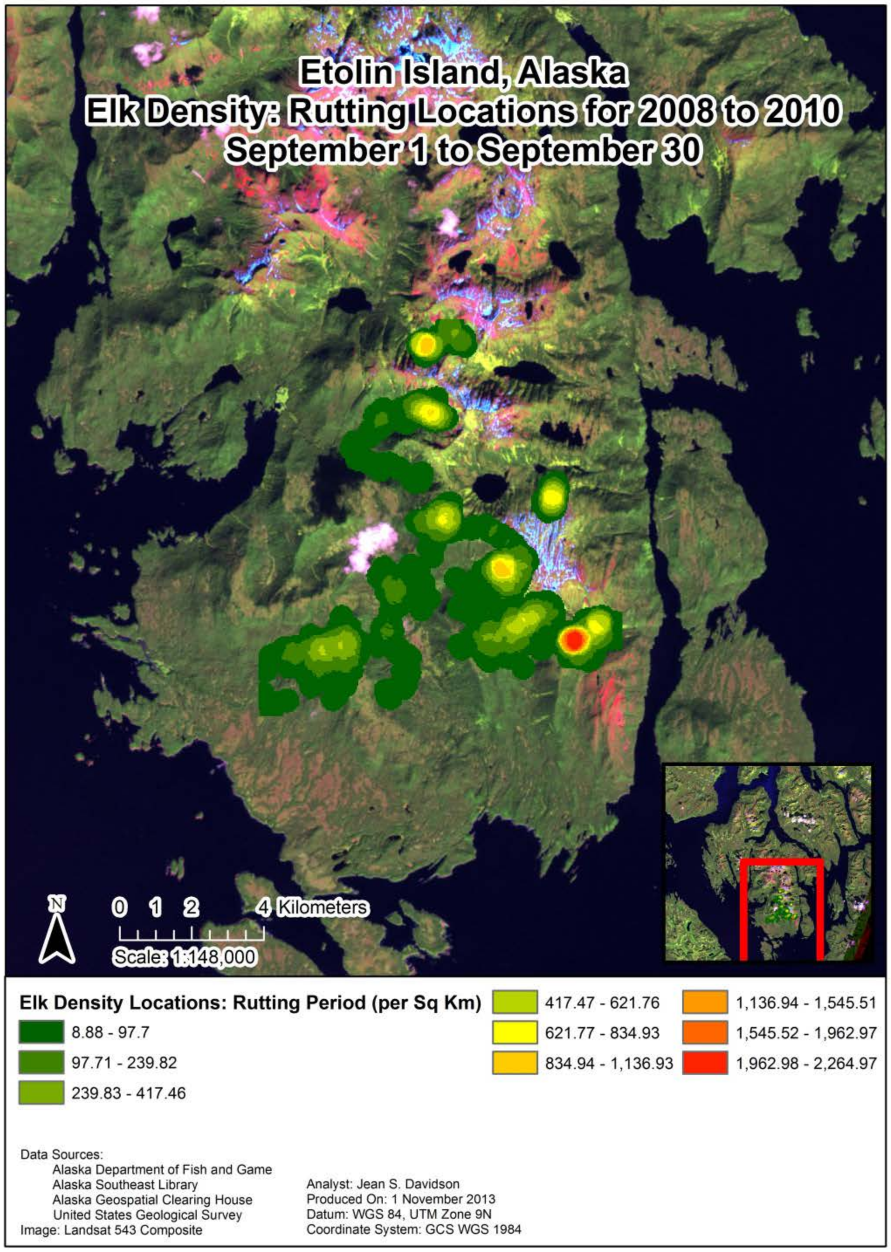

Figure 5. Etolin Island, Elk Density: Rutting Locations

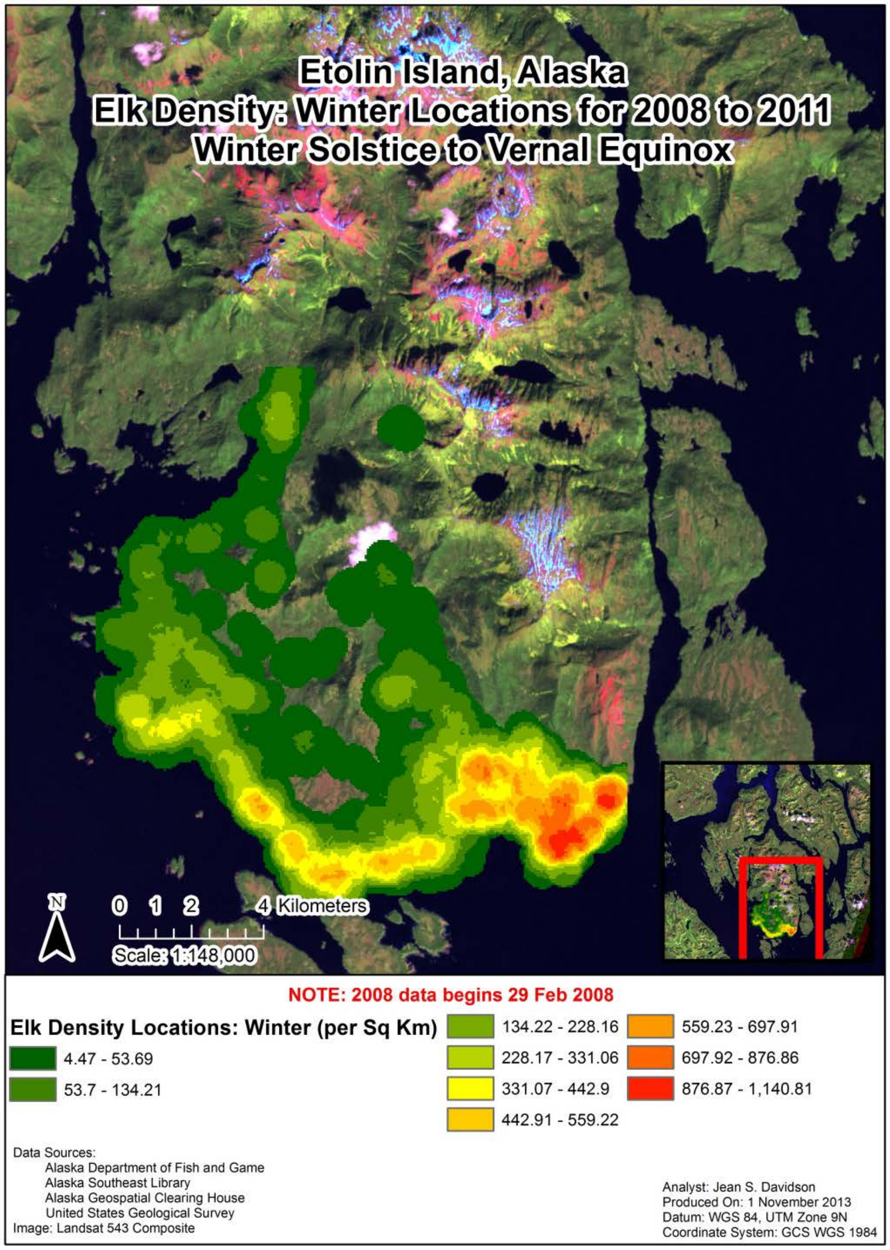

Figure 6. Etolin Island, Elk Density: Winter Solstice to Vernal Equinox

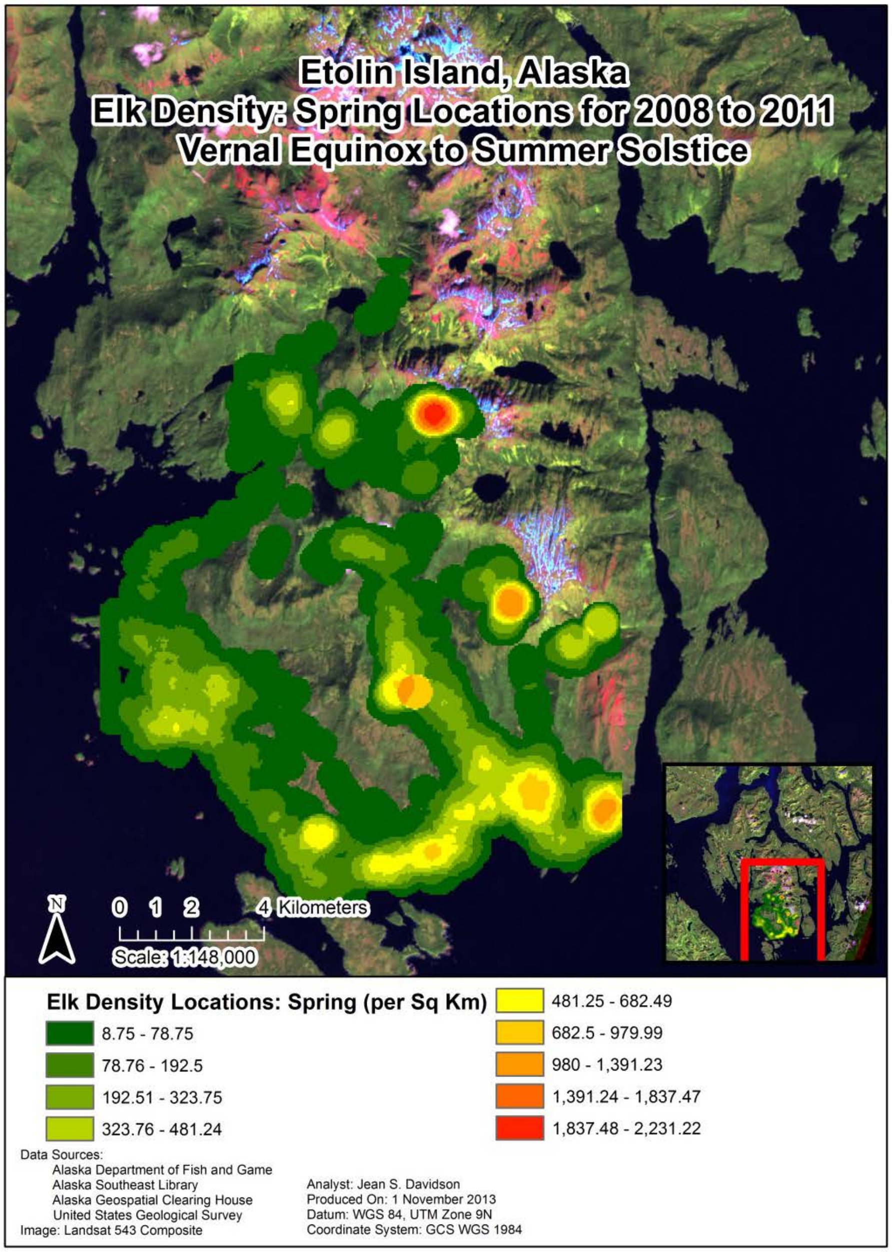

Figure 7. Etolin Island, Elk Density: Vernal Equinox to Summer Solstice

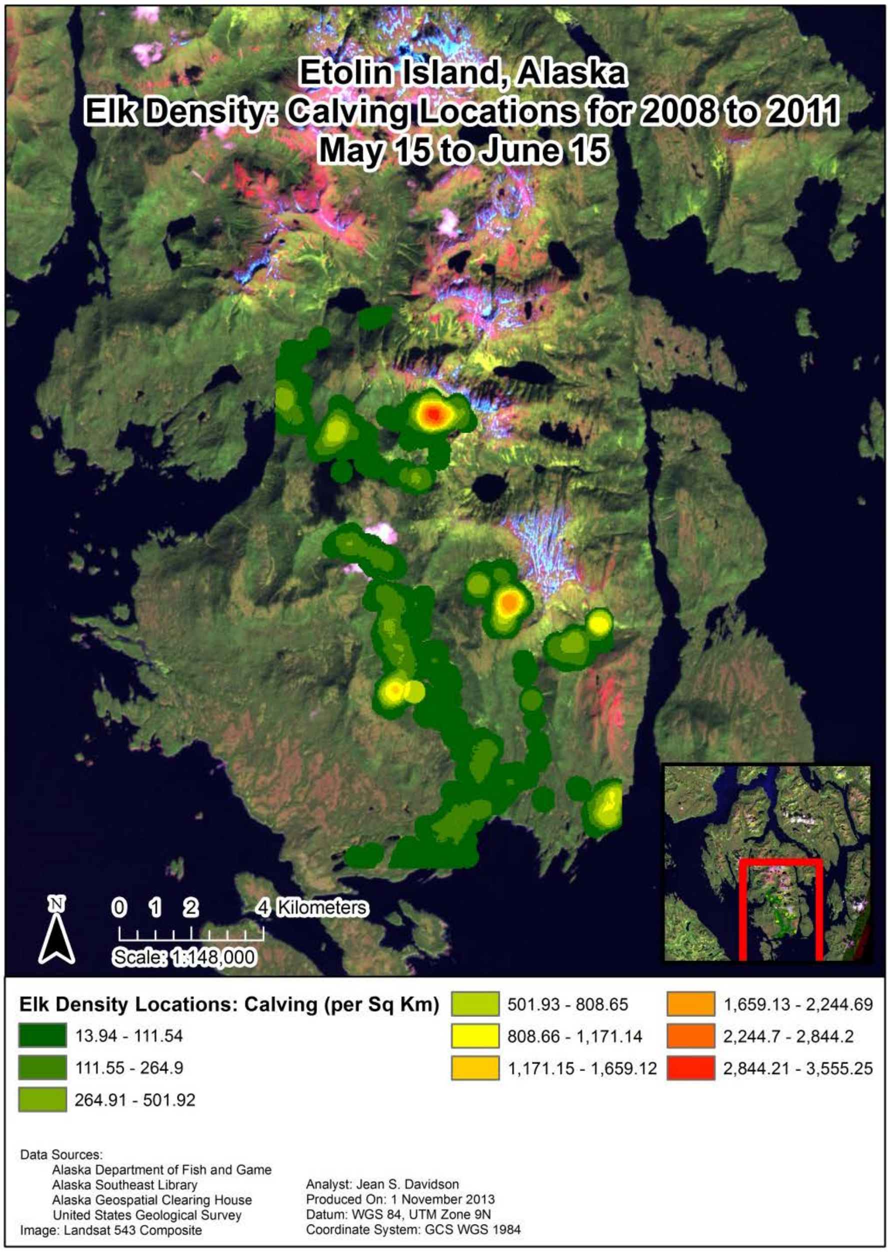

Figure 8. Etolin Island, Elk Density: Calving Locations

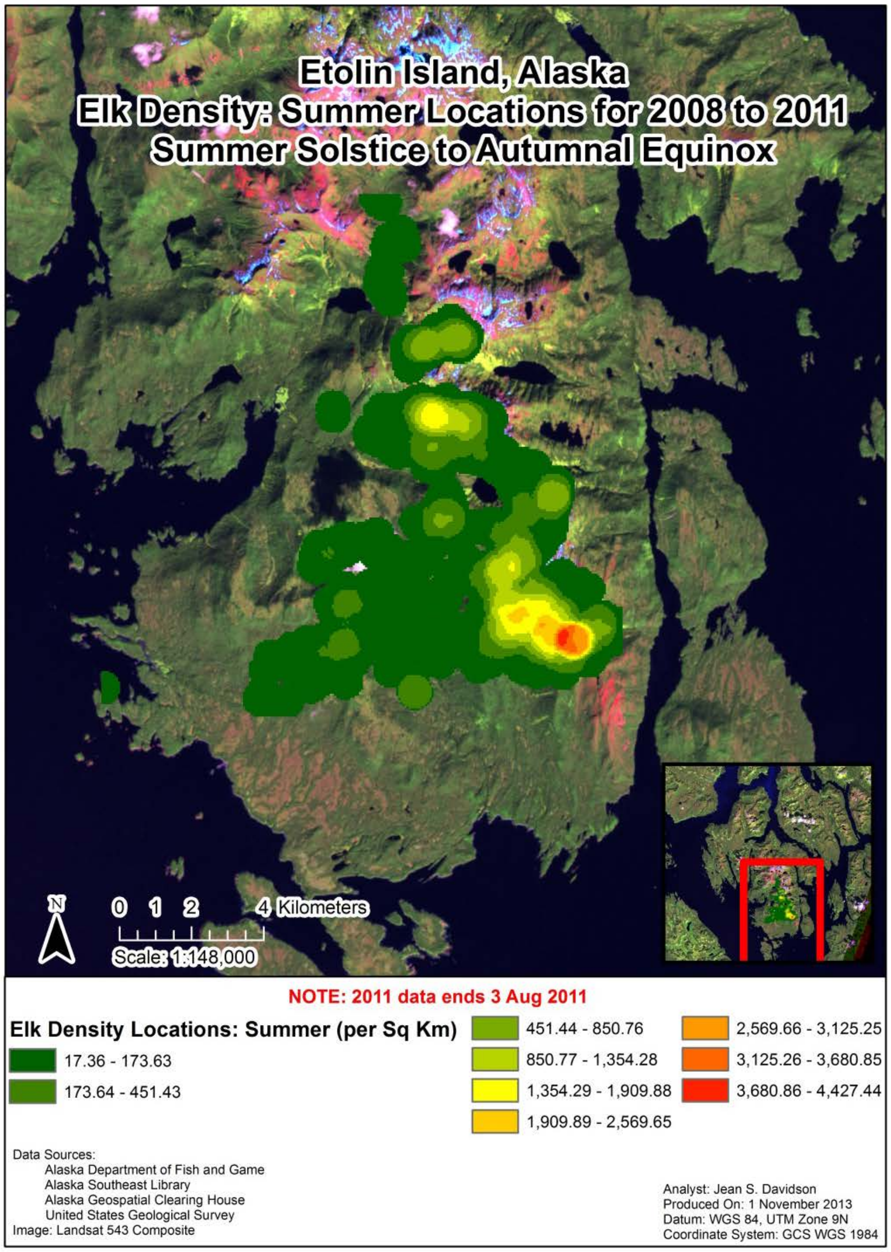

Figure 9. Etolin Island, Elk Density: Summer Solstice to Autumnal Equinox

Table 3. Etolin Island, Elk Preference to Proximity to Streams

Proximity to Streams (in meters)

	All	Day	Night	Calving
Number of Records	63,643	36,660	26,983	6,469
Minimum	0.006430	0.006432	0.009407	0.041047
Maximum	1,856.40	2,066.72	2,053.19	1,739.46
Mean	337.75	432.78	407.12	554.55
Standard Deviation	390.06	430.37	380.49	525.91

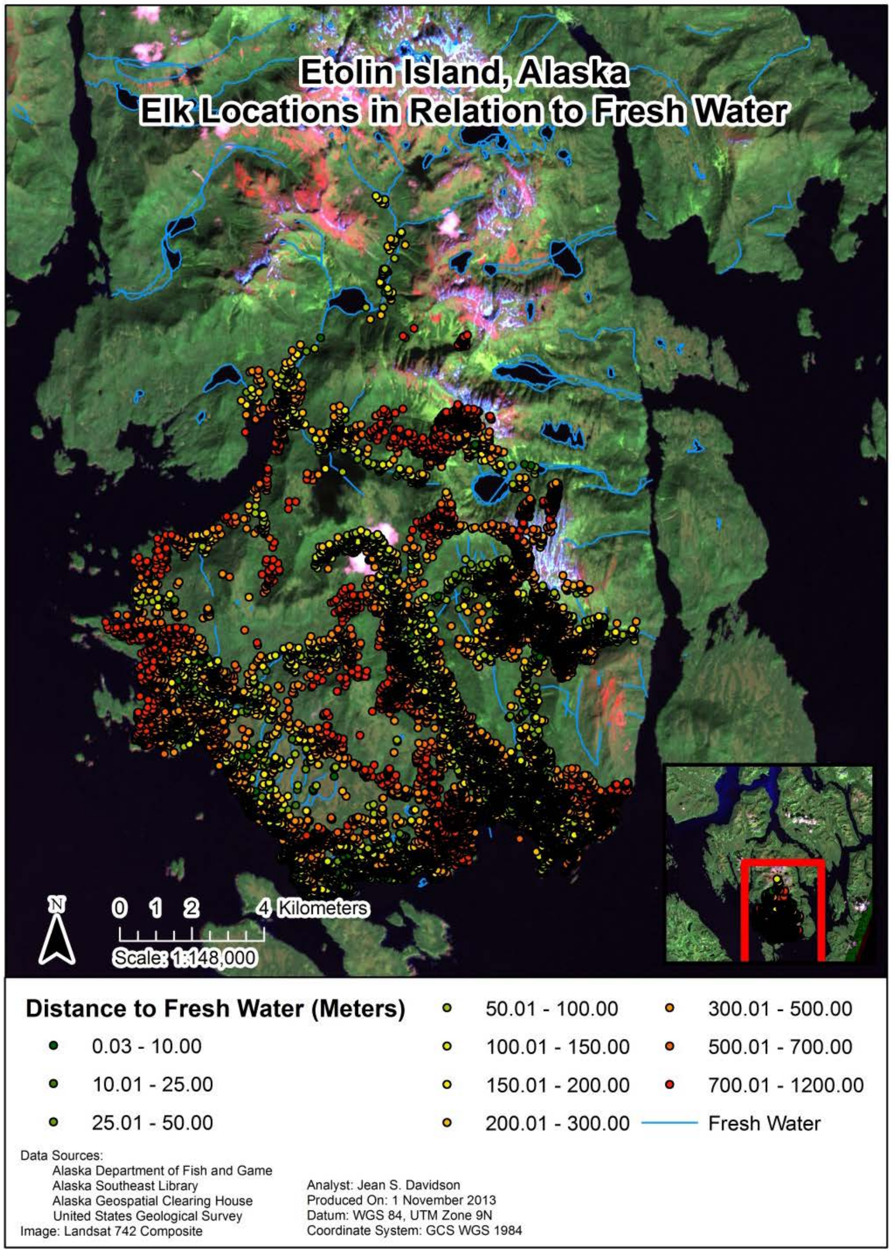

Figure 10. Etolin Island, Elk Locations in Relation to Fresh Water

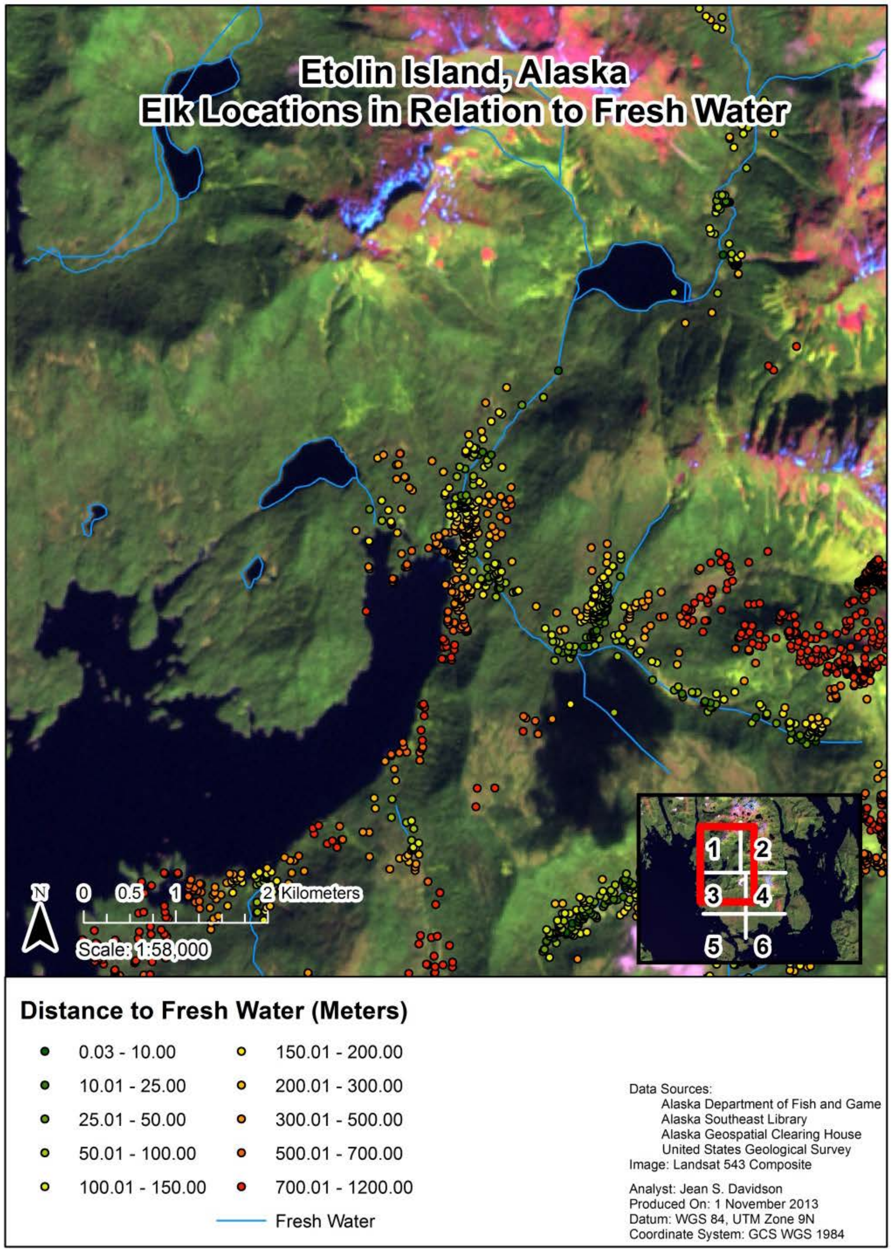

Figure 11. Etolin Island, Elk Locations in Relation to Fresh Water, Subset 1

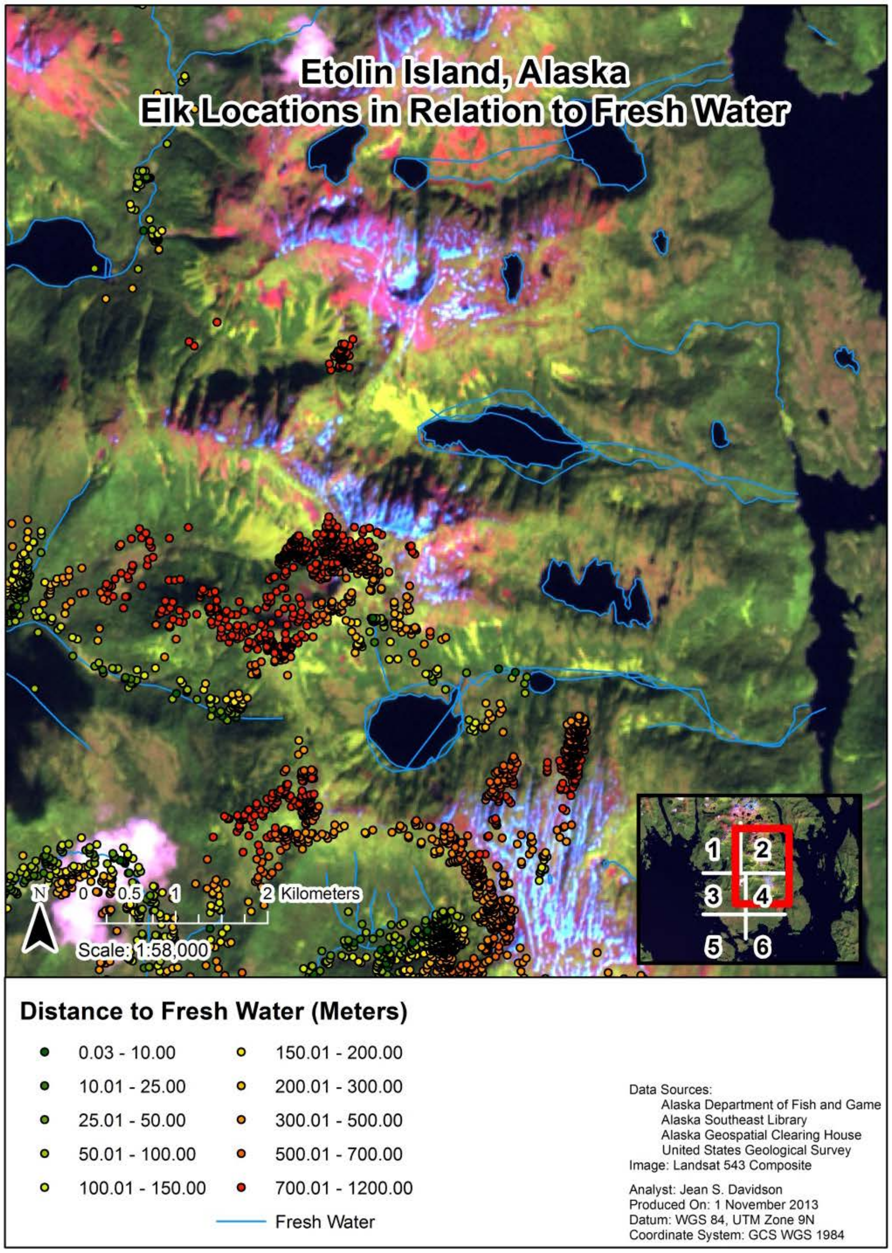

Figure 12. Etolin Island, Elk Locations in Relation to Fresh Water, Subset 2

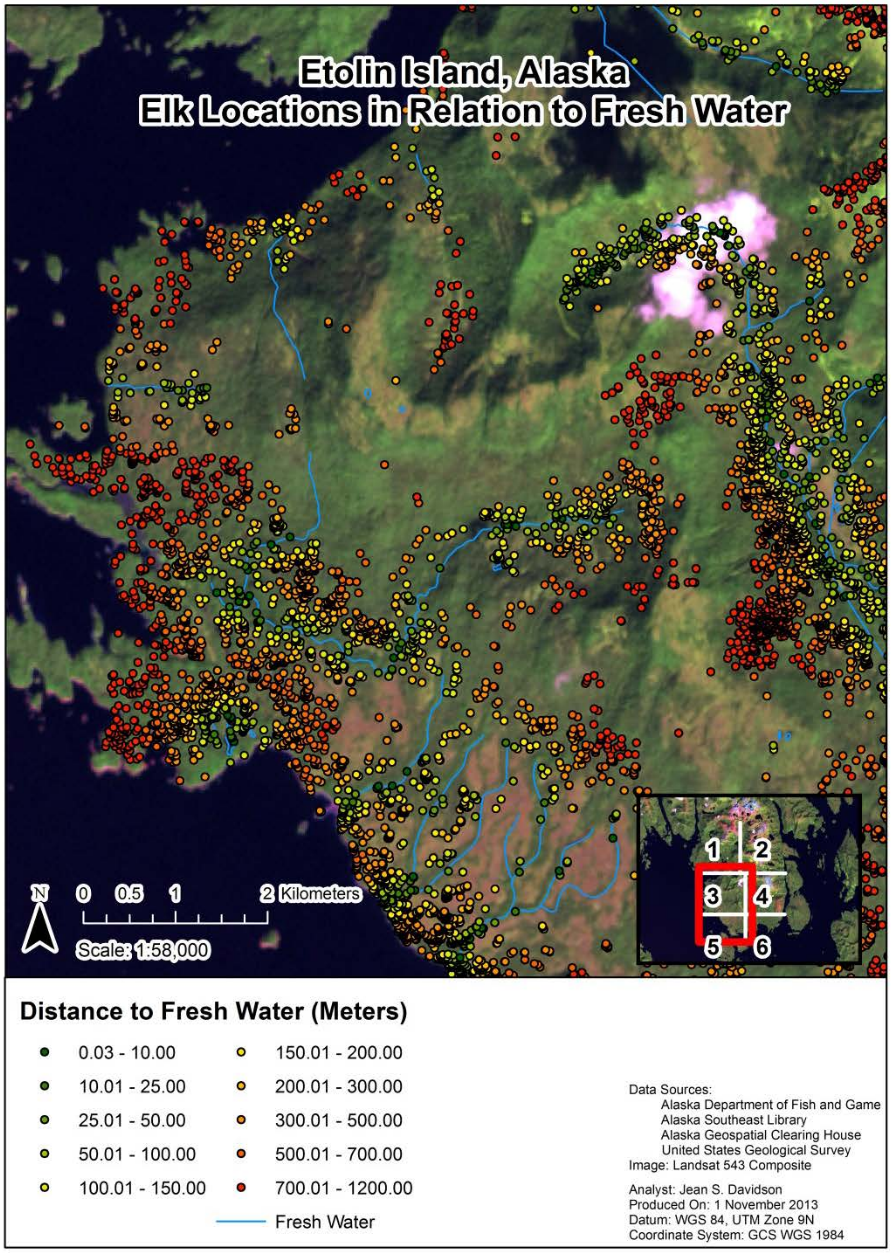

Figure 13. Etolin Island, Elk Locations in Relation to Fresh Water, Subset 3

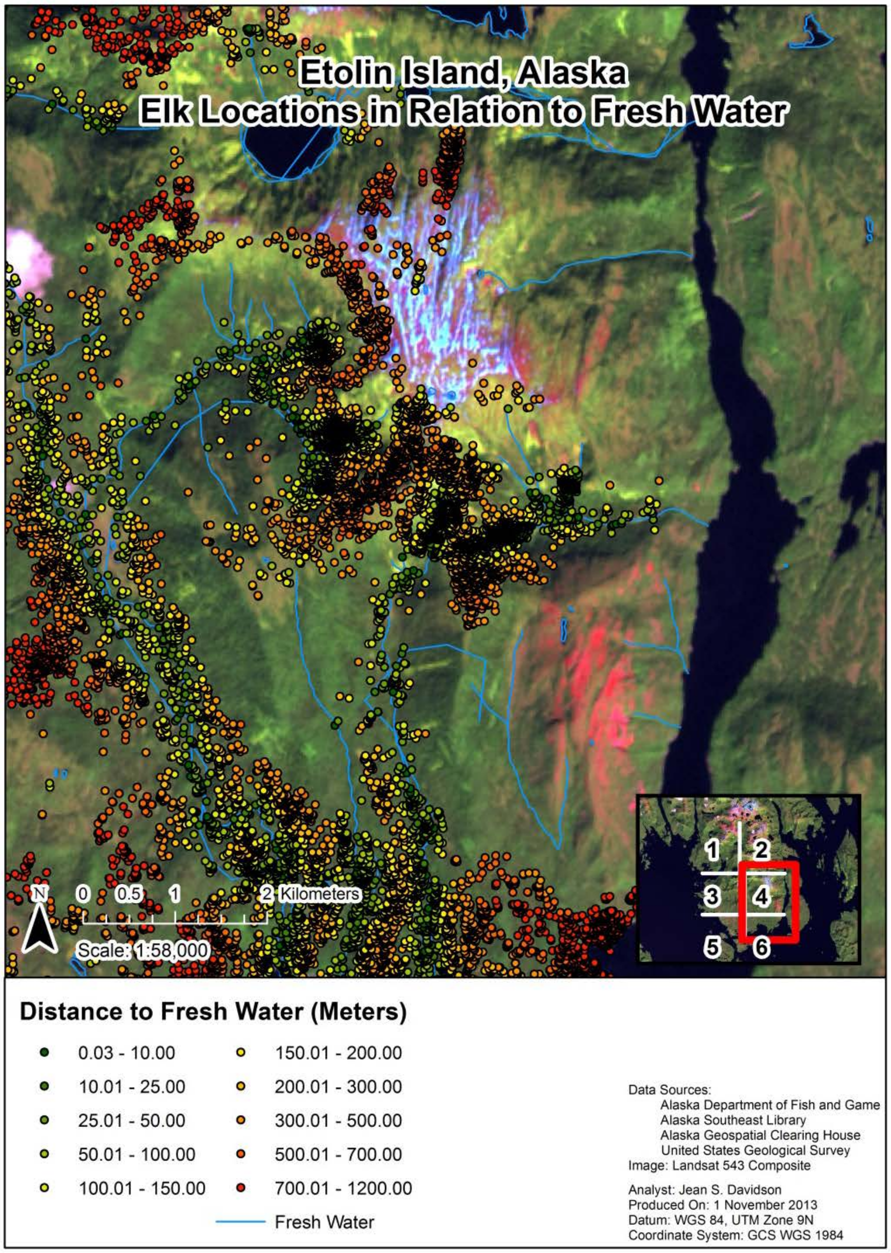

Figure 14. Etolin Island, Elk Locations in Relation to Fresh Water, Subset 4

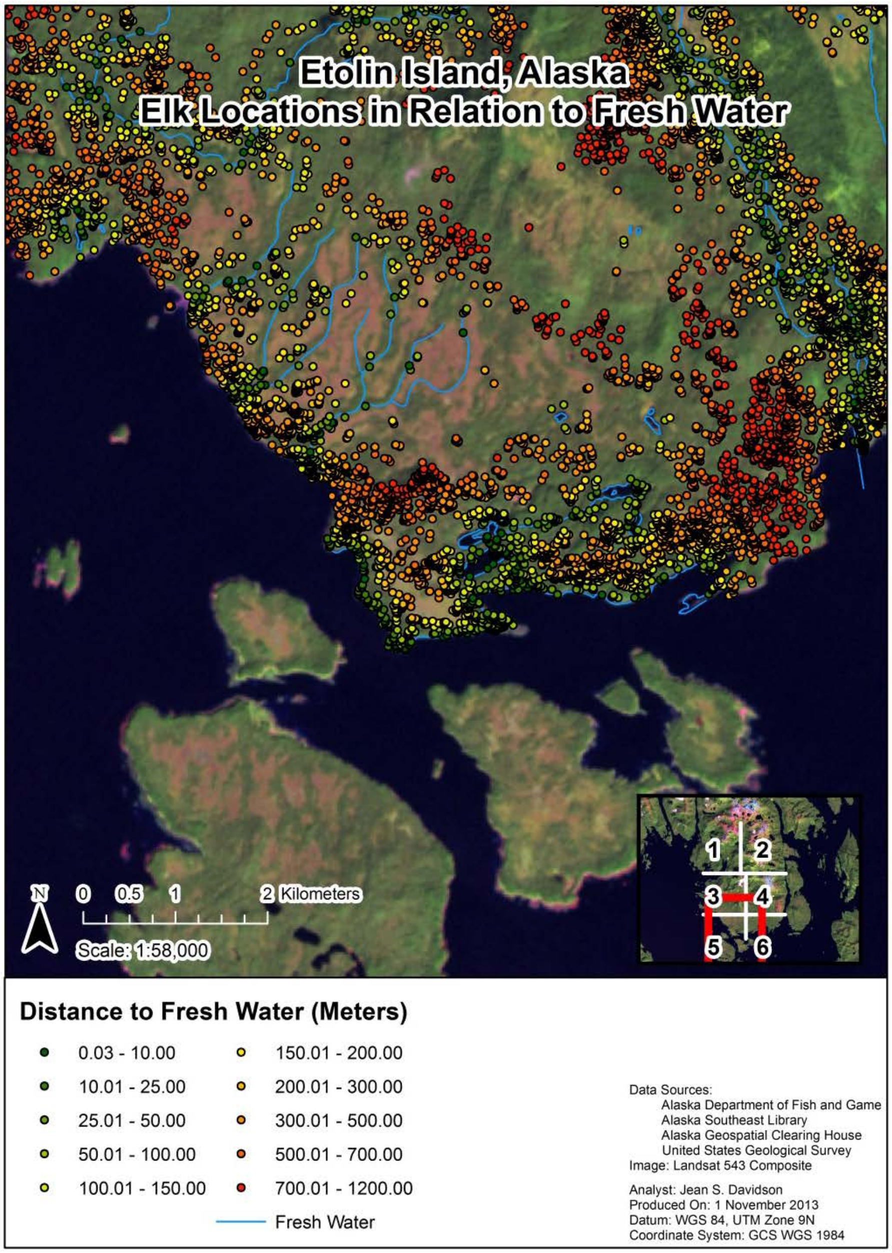

Figure 15. Etolin Island, Elk Locations in Relation to Fresh Water, Subset 5

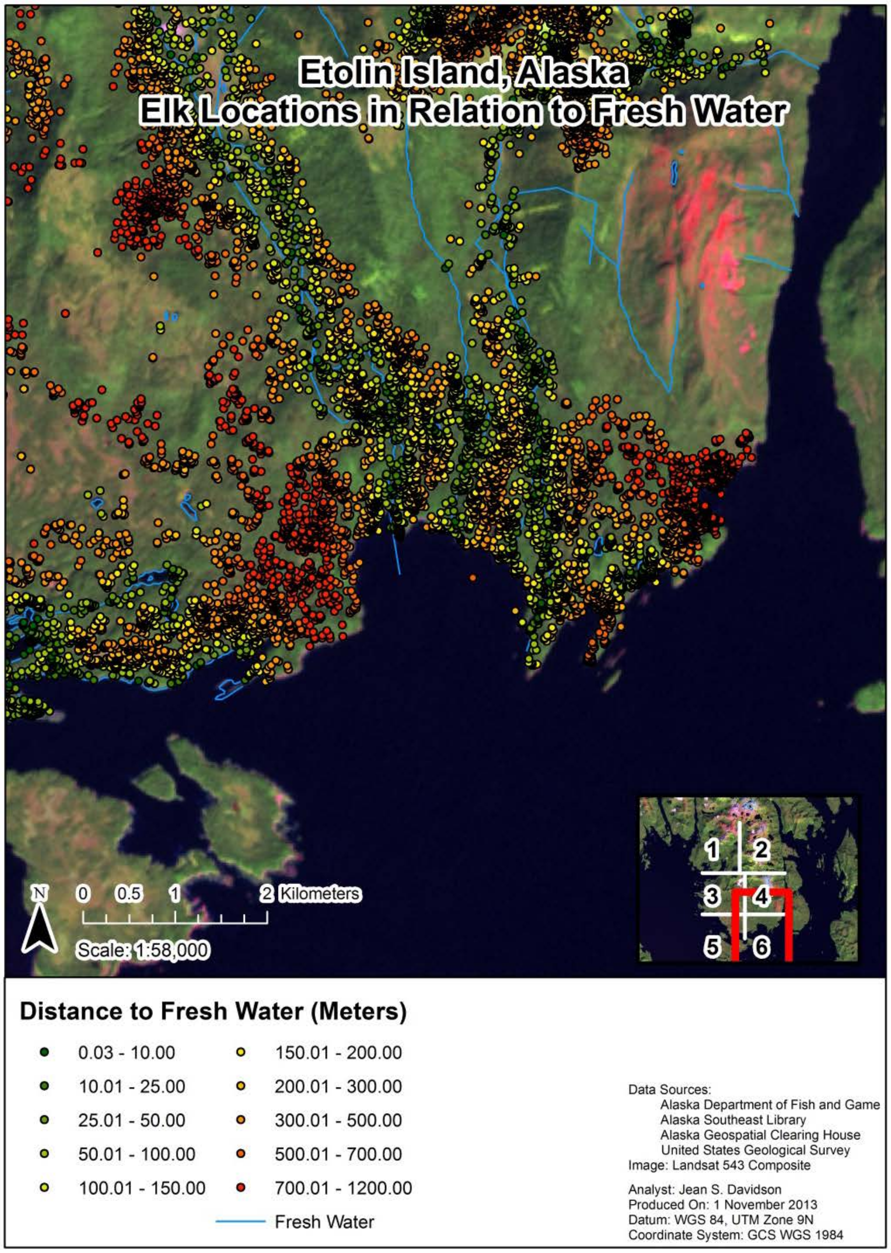

Figure 16. Etolin Island, Elk Locations in Relation to Fresh Water, Subset 6

Table 4. Etolin Island, Elk Preference to Slope Percentage

Elk Preference to Slope Percentage

	All	Day	Night	*Calving
Number of Records	63,643	36,660	26,983	6,469
Minimum	0	0	0	0
Maximum	69	67	69	63
Mean	13.04	14.39	11.22	16.89
Standard Deviation	11.54	11.86	10.83	11.71

* Calving numbers include both day and night elk locations.

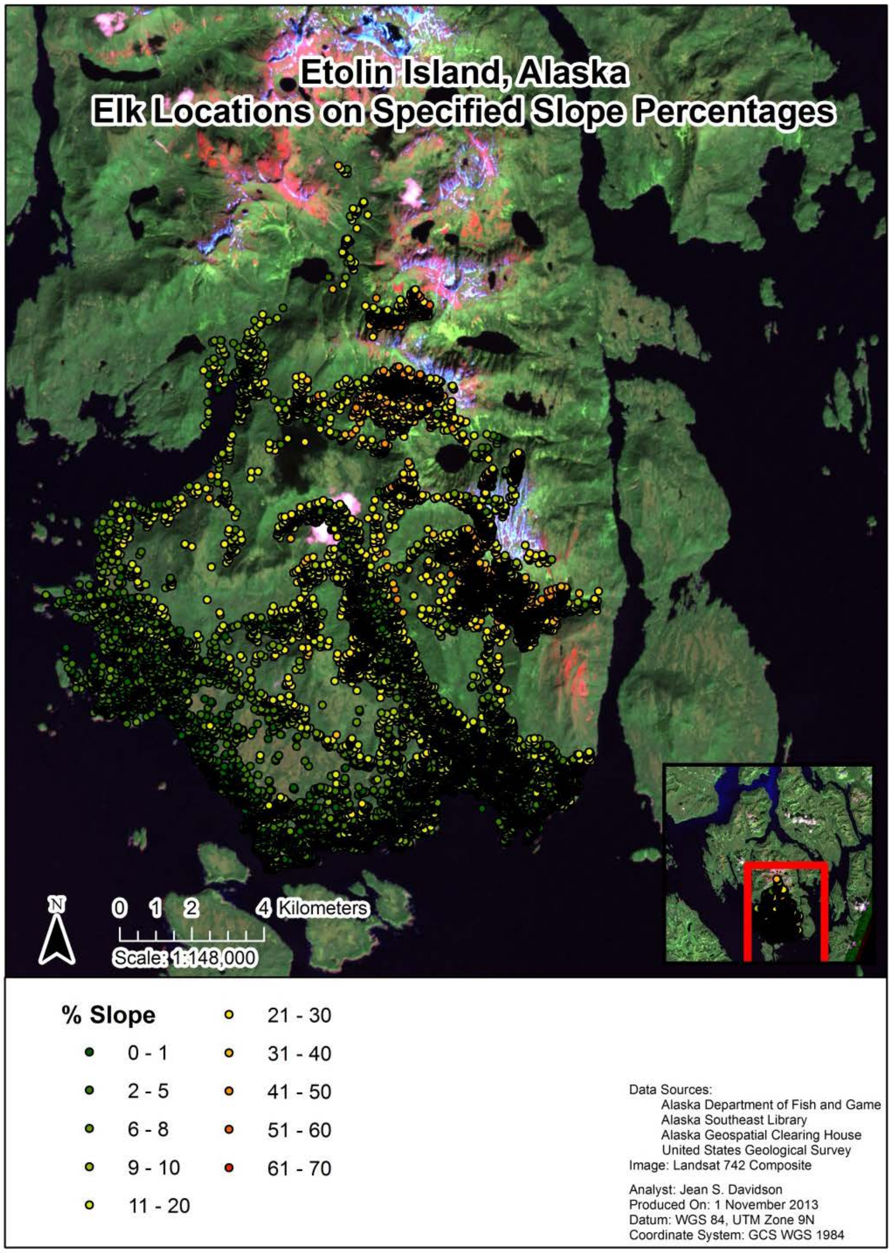

Figure 17. Etolin Island, Elk Locations on Specified Slope Percentages

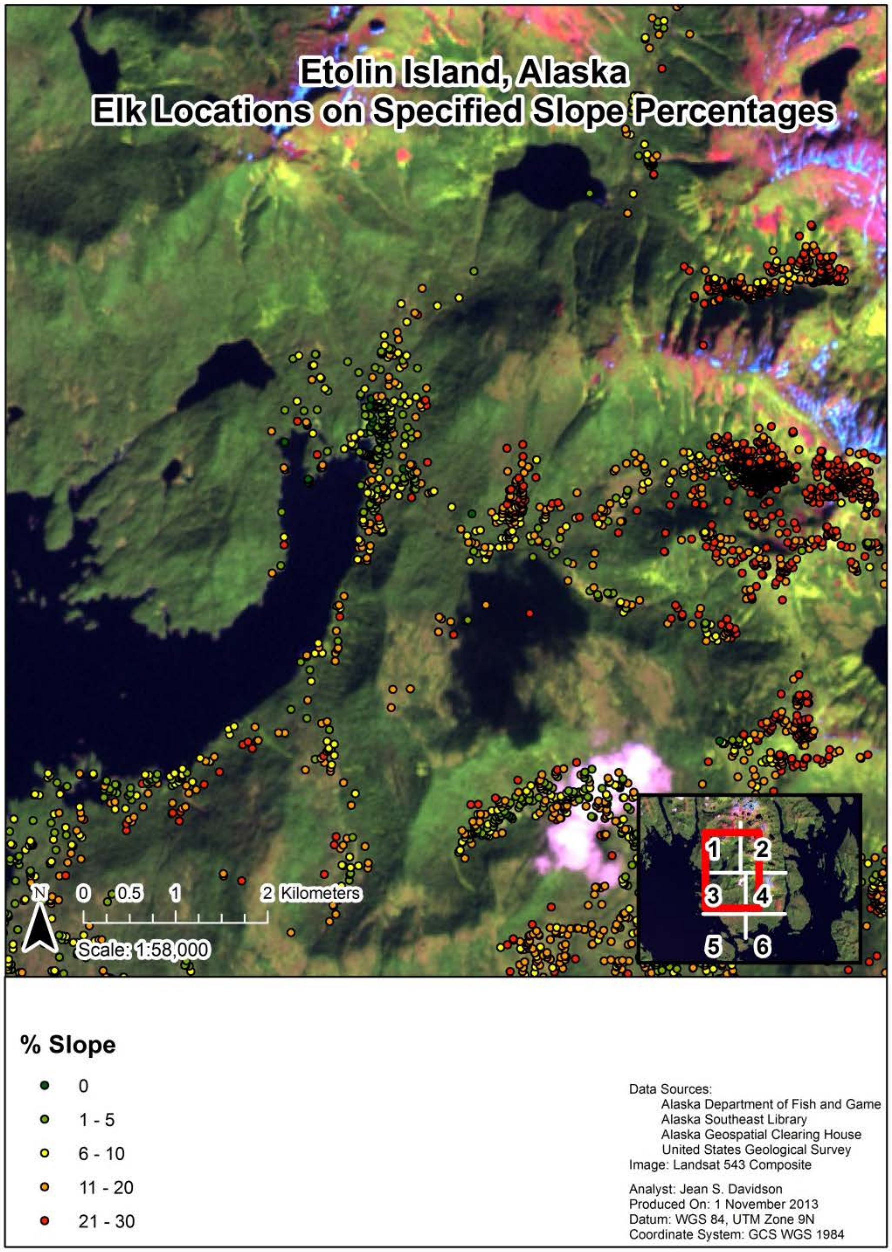

Figure 18. Etolin Island, Elk Locations on Specified Slope Percentages, Subset 1

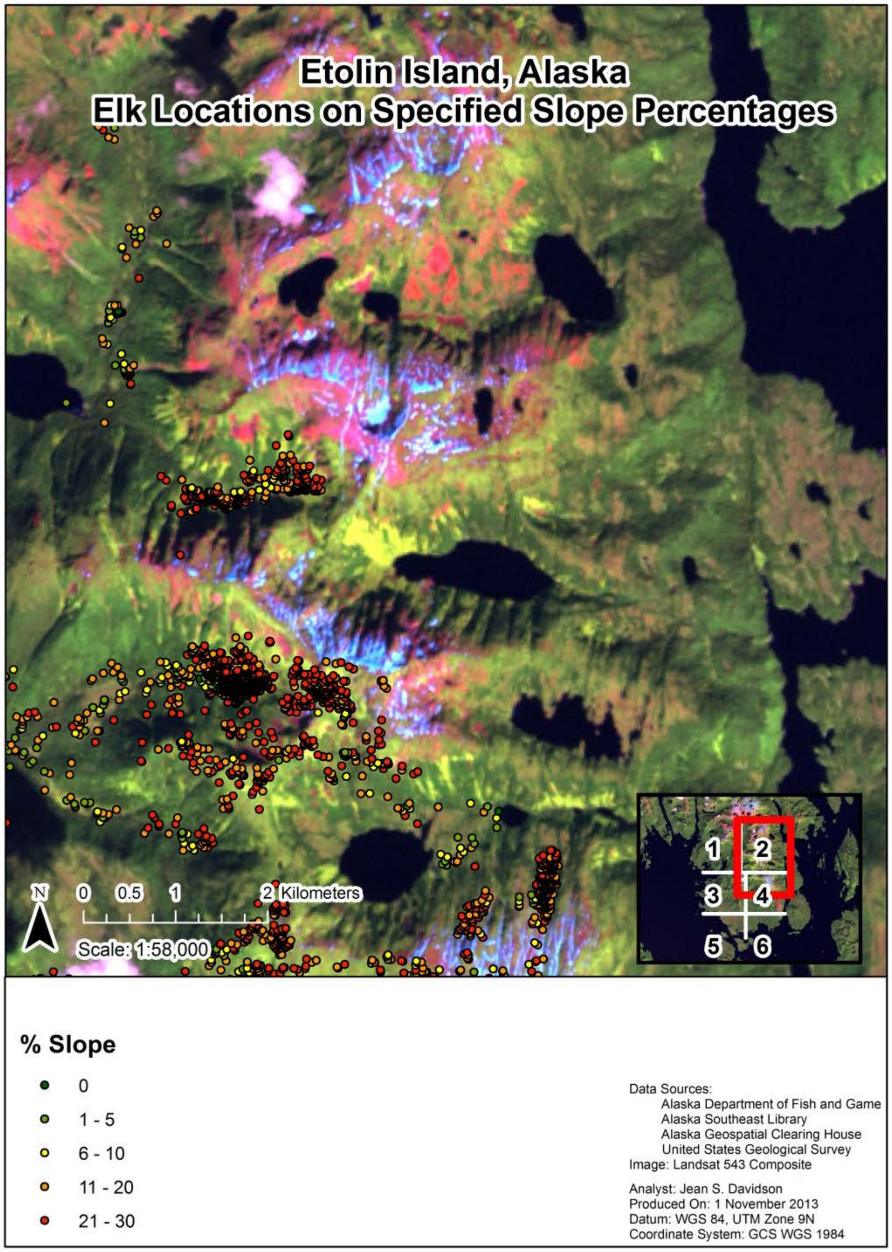

Figure 19. Etolin Island, Elk Locations on Specified Slope Percentages, Subset 2

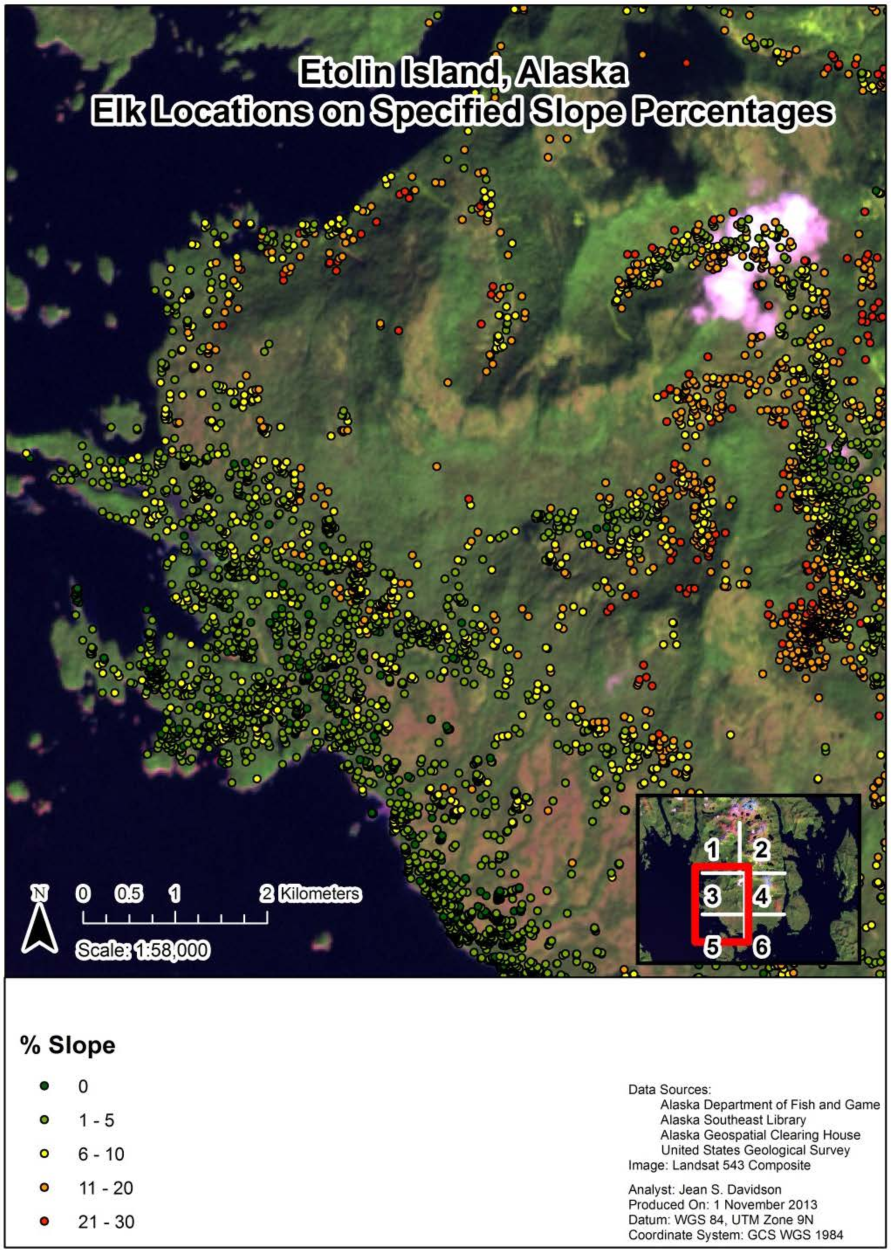

Figure 20. Etolin Island, Elk Locations on Specified Slope Percentages, Subset 3

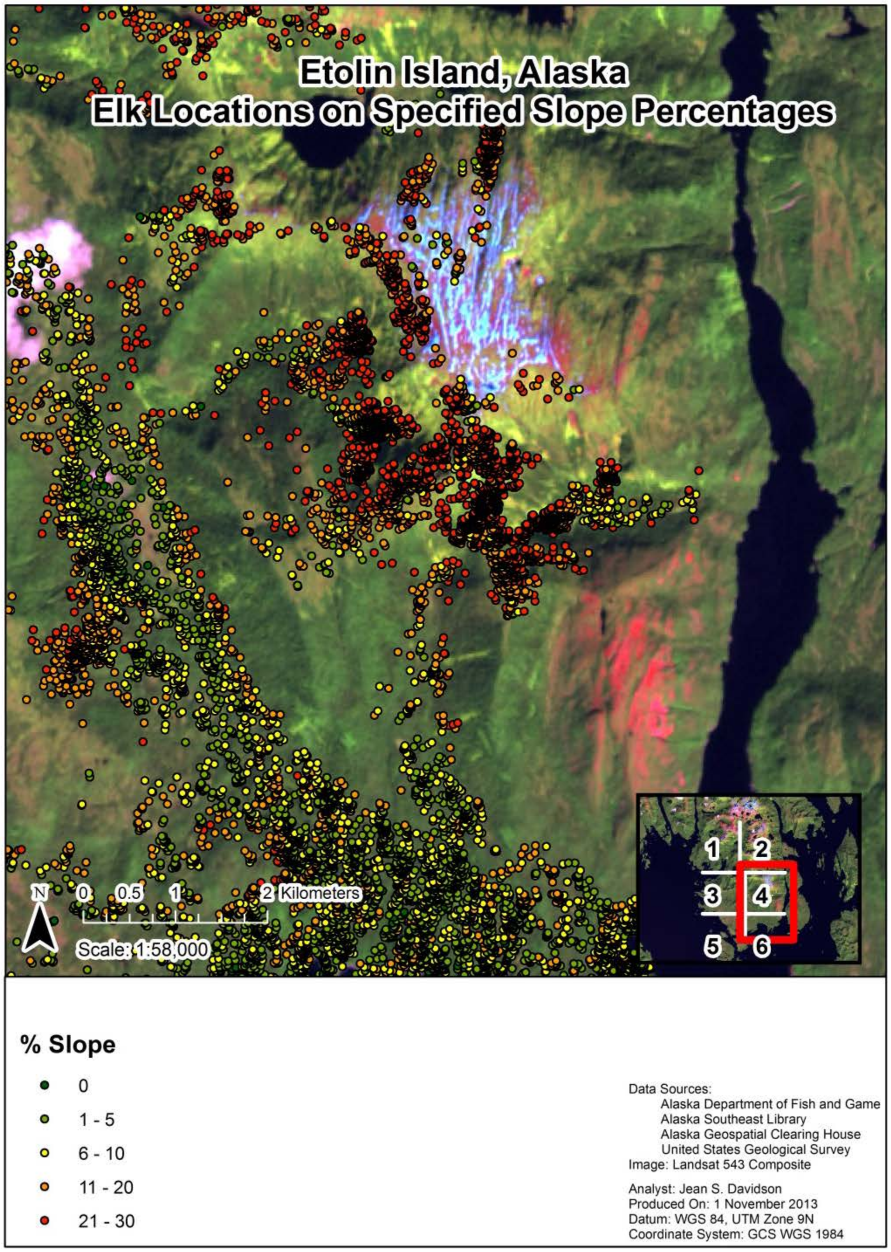

Figure 21. Etolin Island, Elk Locations on Specified Slope Percentages, Subset 4

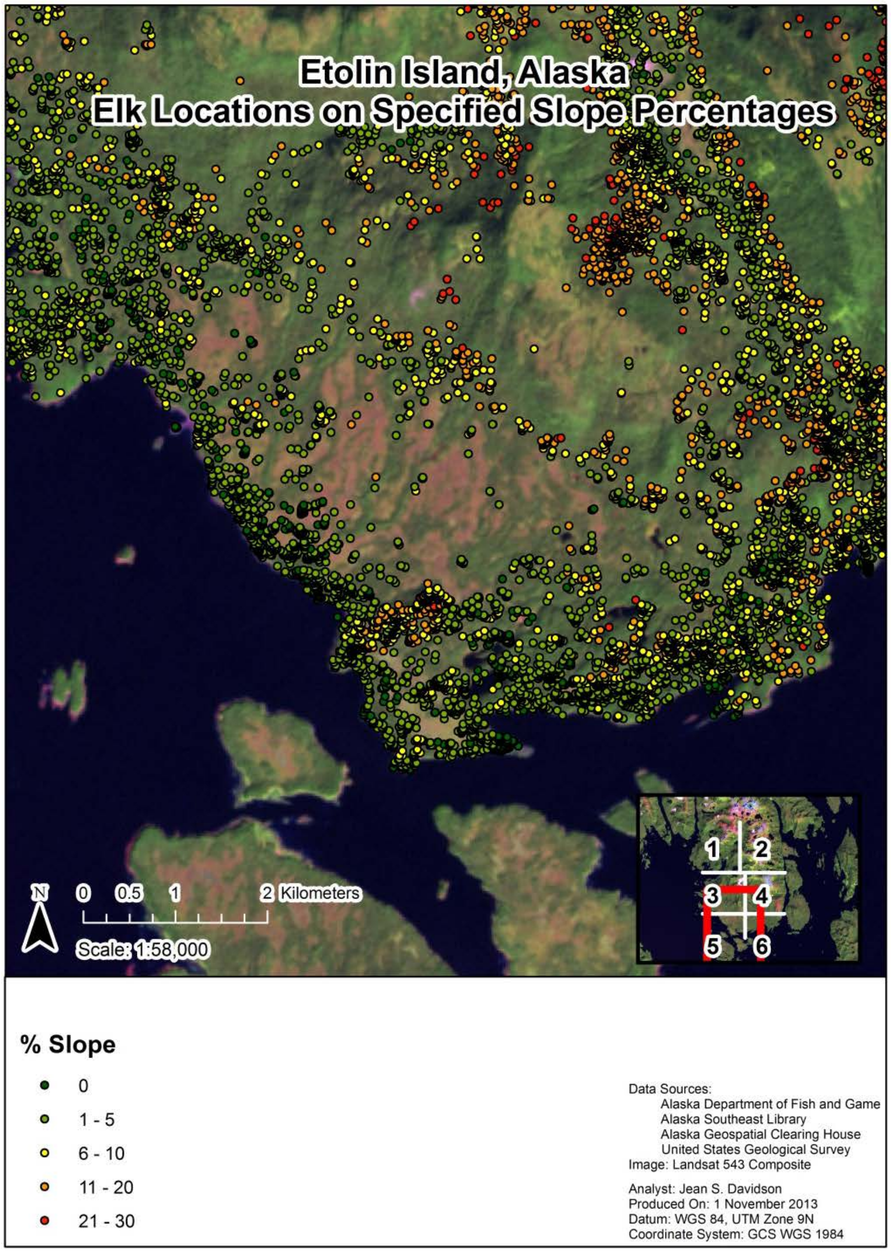

Figure 22. Etolin Island, Elk Locations on Specified Slope Percentages, Subset 5

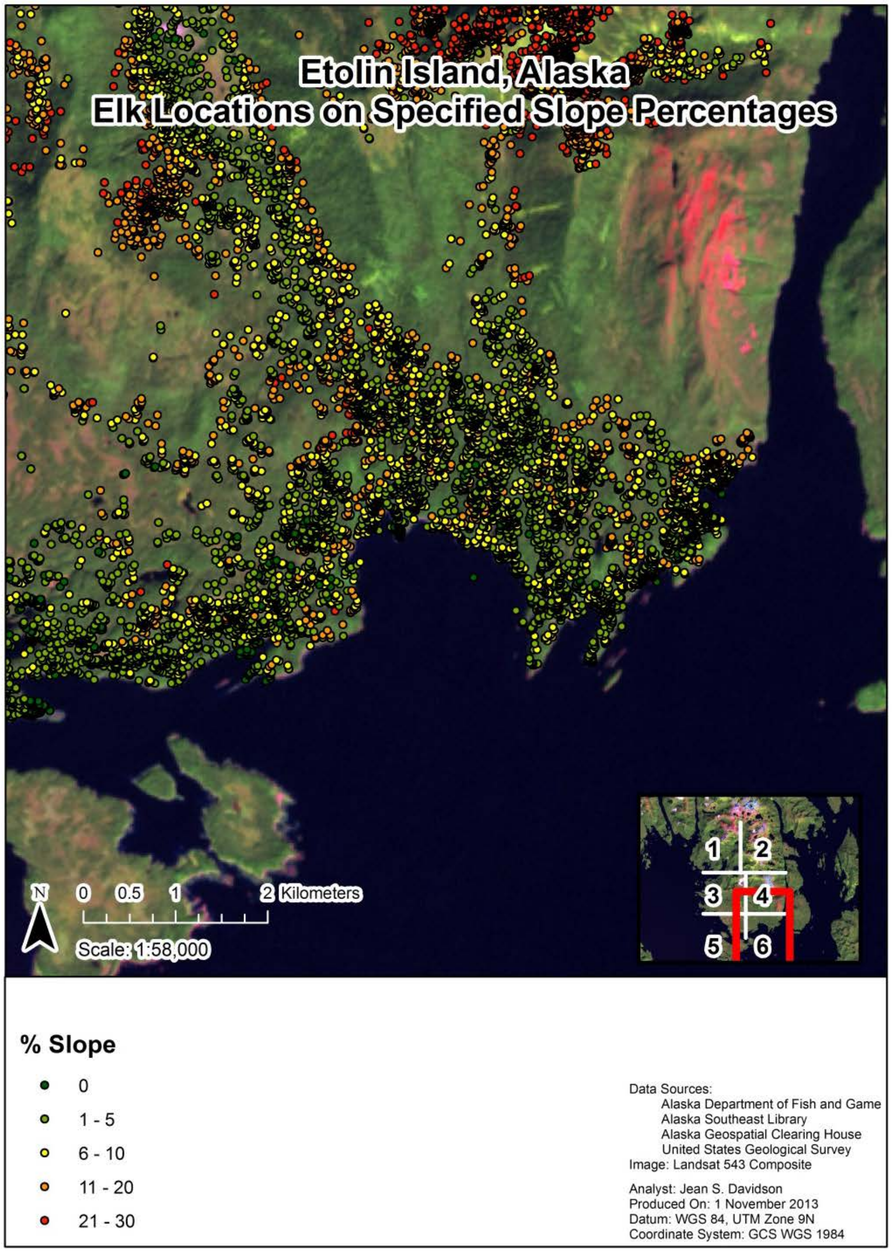

Figure 23. Etolin Island, Elk Locations on Specified Slope Percentages, Subset 6

Table 5. Etolin Island, Elk Preference to Managed and Unmanaged Lands

Elk Preference to Managed and Unmanaged Lands

	All		Day		Night		Calving	
	Count	%	Count	%	Count	%	Count	%
Miscellaneous/ Unknown	2,512	3.95%	1,370	3.74%	1,142	4.23%	54	0.83%
Forested Muskeg	531	0.83%	353	0.96%	178	0.66%	90	1.39%
Cut Age < 20	0	0.00%	0	0.00%	0	0.00%	0	0.00%
Cut Age >= 20 and <= 50	0	0.00%	0	0.00%	0	0.00%	0	0.00%
Cut Age > 50	247	0.39%	162	0.44%	85	0.32%	24	0.37%
Non-Forest	12,970	20.38%	8,916	24.32%	4,054	15.02%	2,398	37.07%
Young Growth Size 2	403	0.63%	300	0.82%	103	0.38%	72	1.11%
Young Growth Size 3	91	0.14%	70	0.19%	21	0.08%	0	0.00%
Growth Size 4 hydric	14,600	22.94%	7,949	21.68%	6,651	24.65%	1,042	16.11%
Growth Size 4 non-hydric	8,760	13.76%	5,370	14.65%	3,390	12.56%	1,236	19.11%
Unproductive Forest	23,454	36.85%	12,124	33.07%	11,330	41.99%	1,493	23.08%
Water	75	0.12%	46	0.13%	29	0.11%	60	0.93%

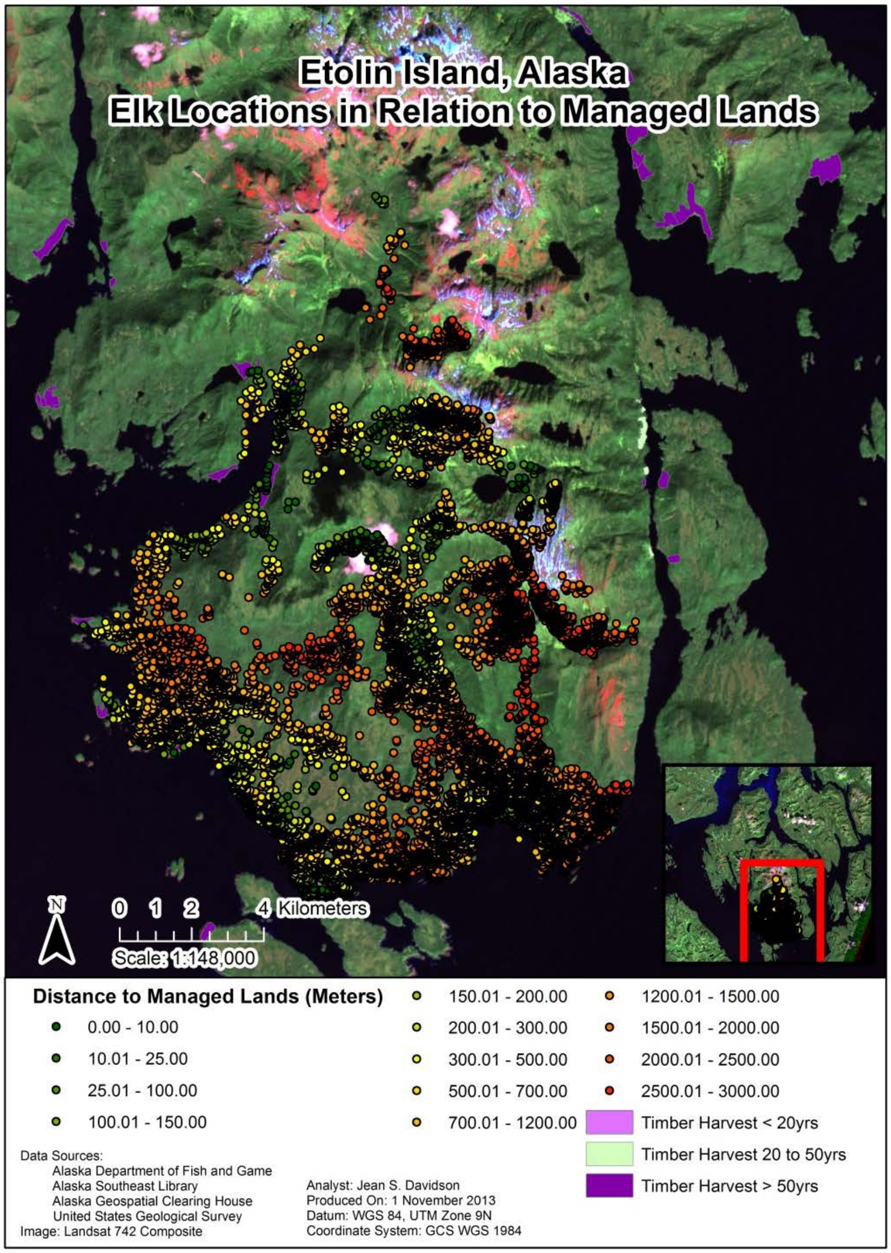

Figure 24. Etolin Island, Elk Locations in Relation to Managed Lands

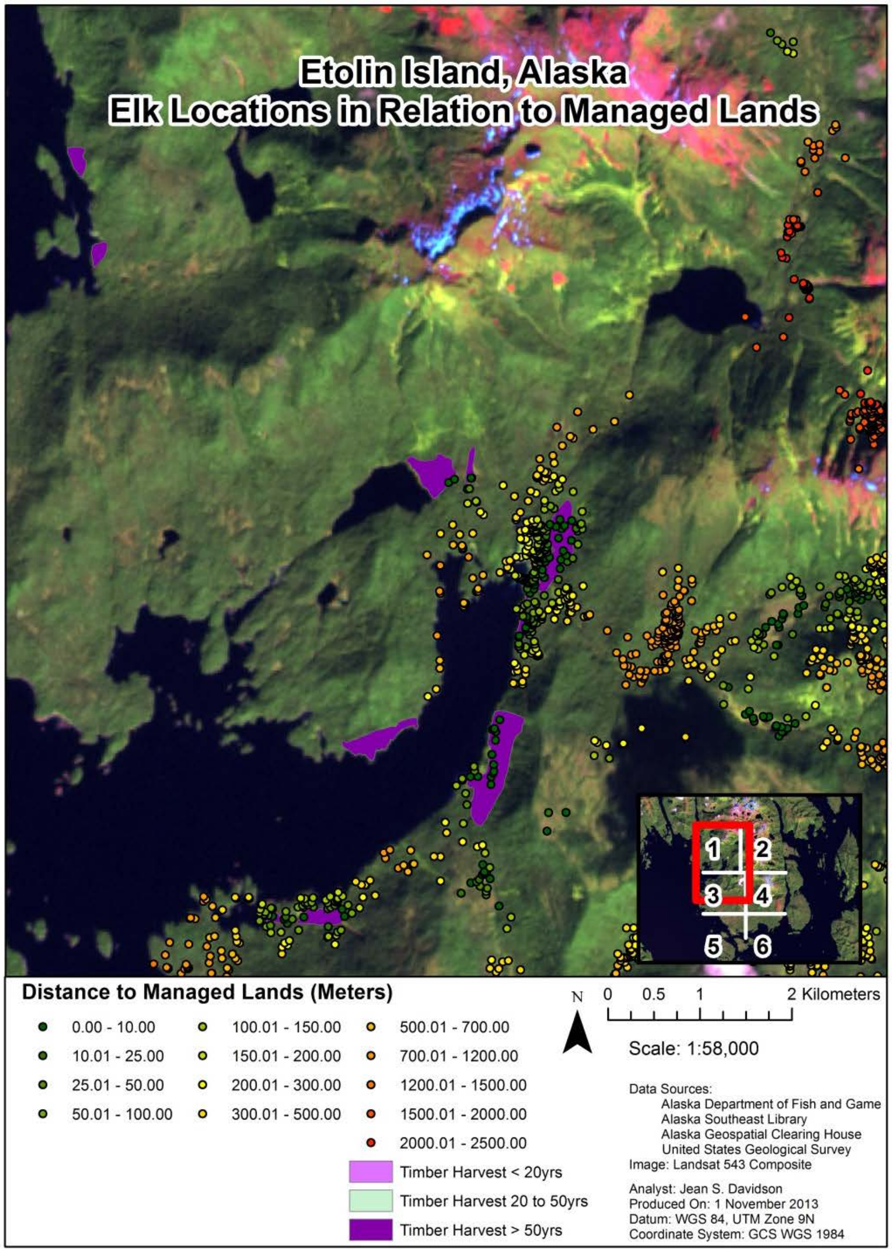

Figure 25. Etolin Island, Elk Locations in Relation to Managed Lands, Subset 1

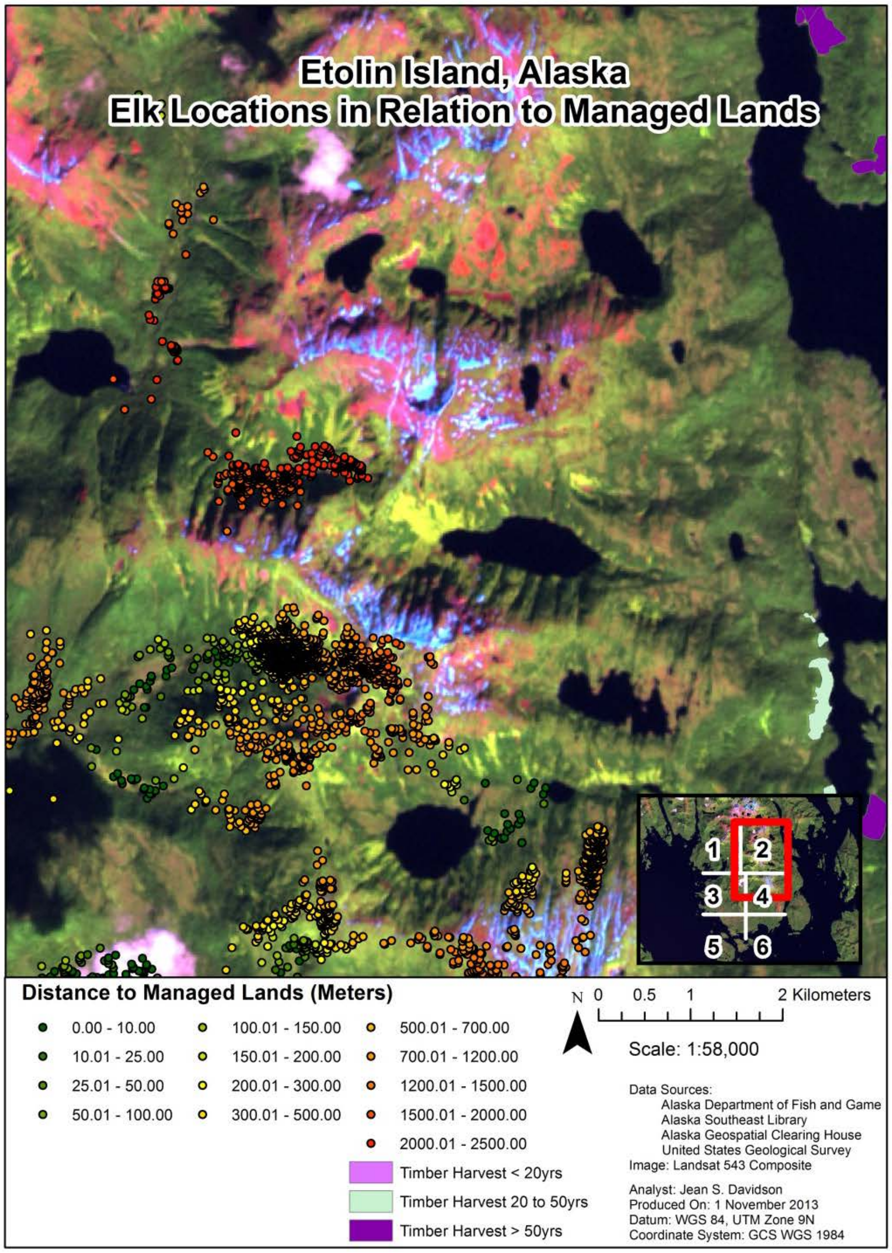

Figure 26. Etolin Island, Elk Locations in Relation to Managed Lands, Subset 2

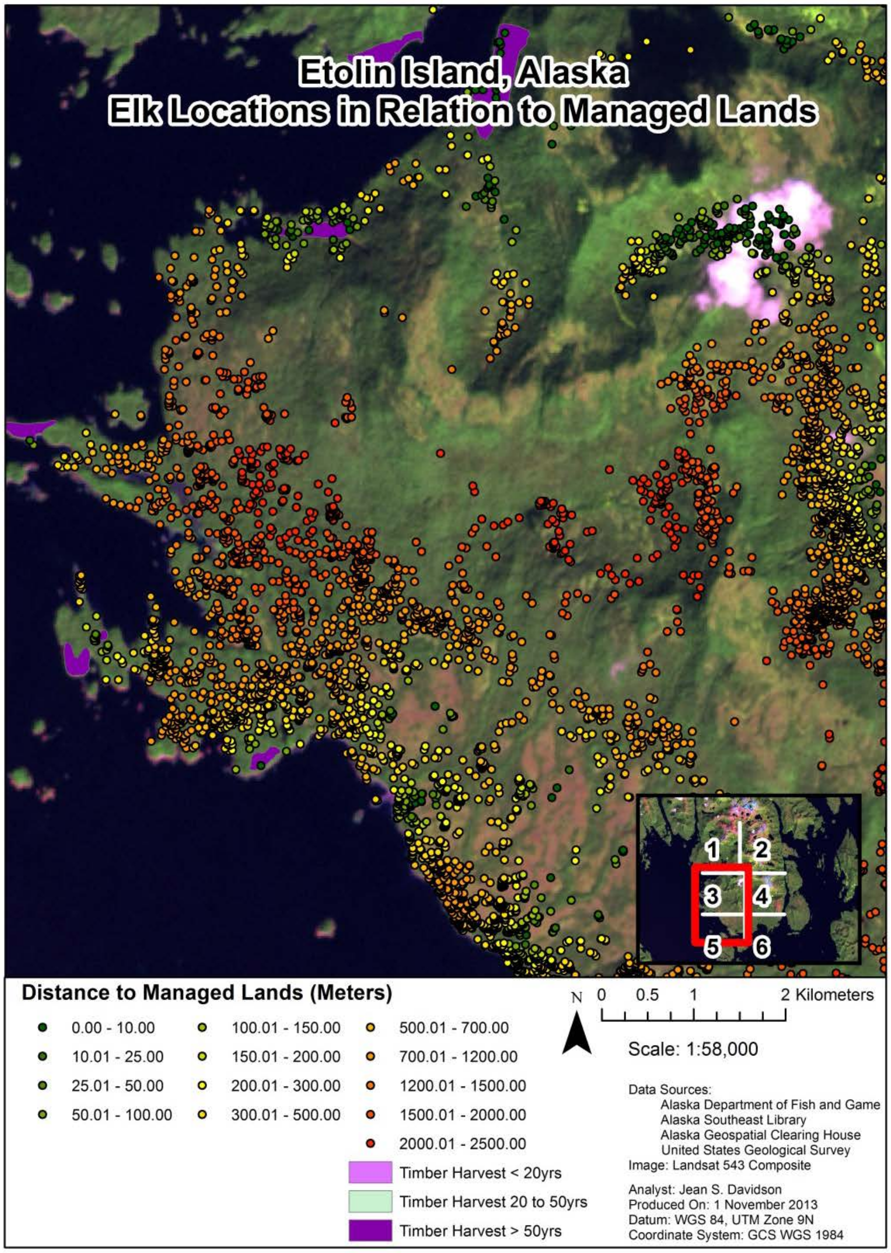

Figure 27. Etolin Island, Elk Locations in Relation to Managed Lands, Subset 3

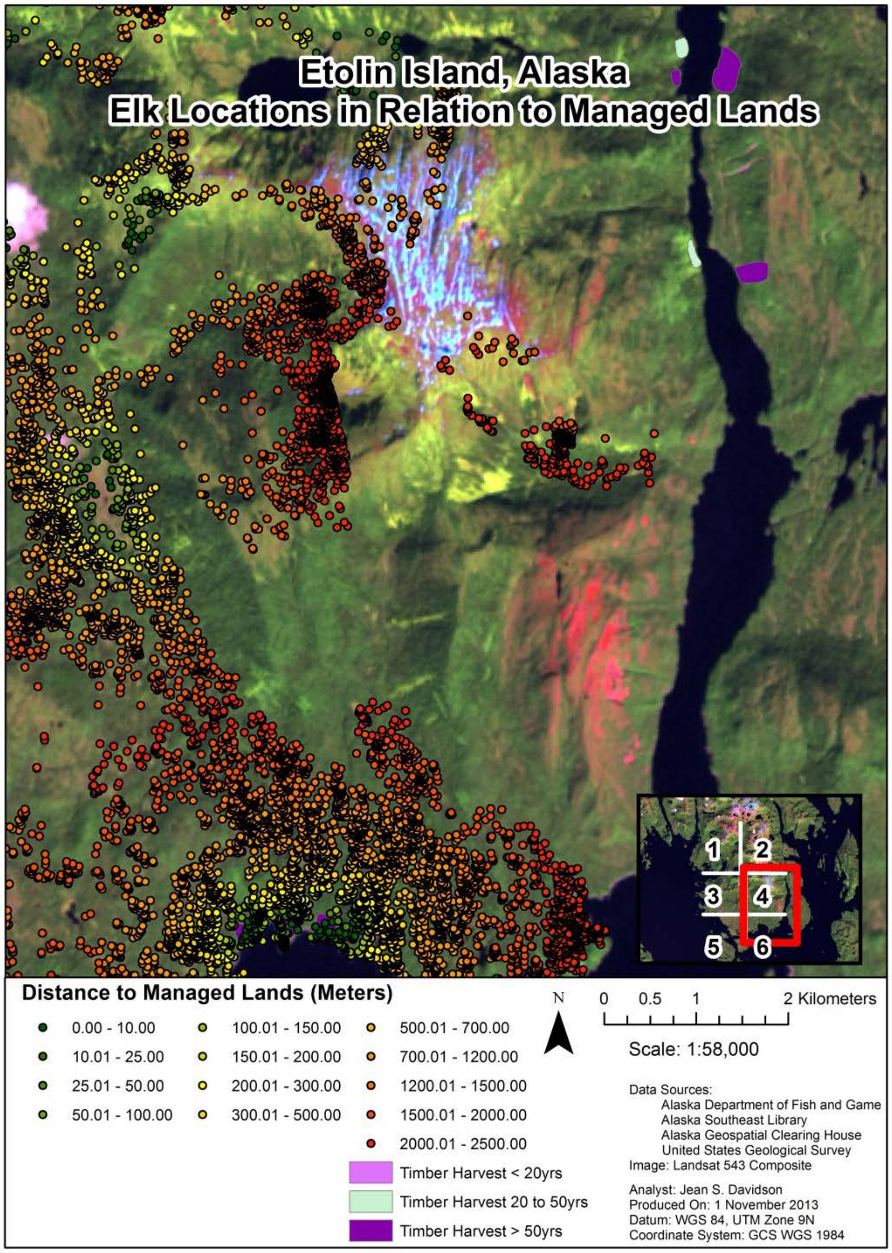

Figure 28. Etolin Island, Elk Locations in Relation to Managed Lands, Subset 4

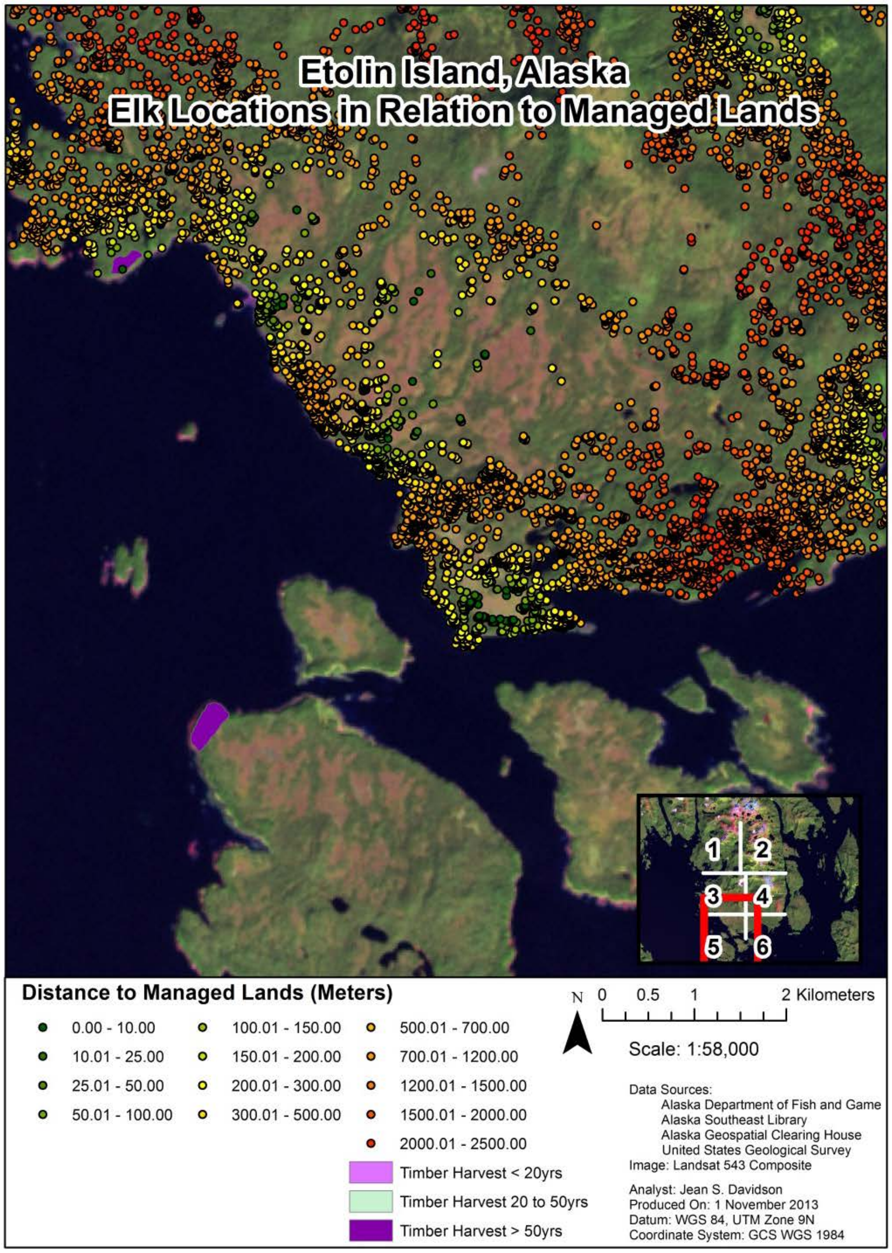

Figure 29. Etolin Island, Elk Locations in Relation to Managed Lands, Subset 5

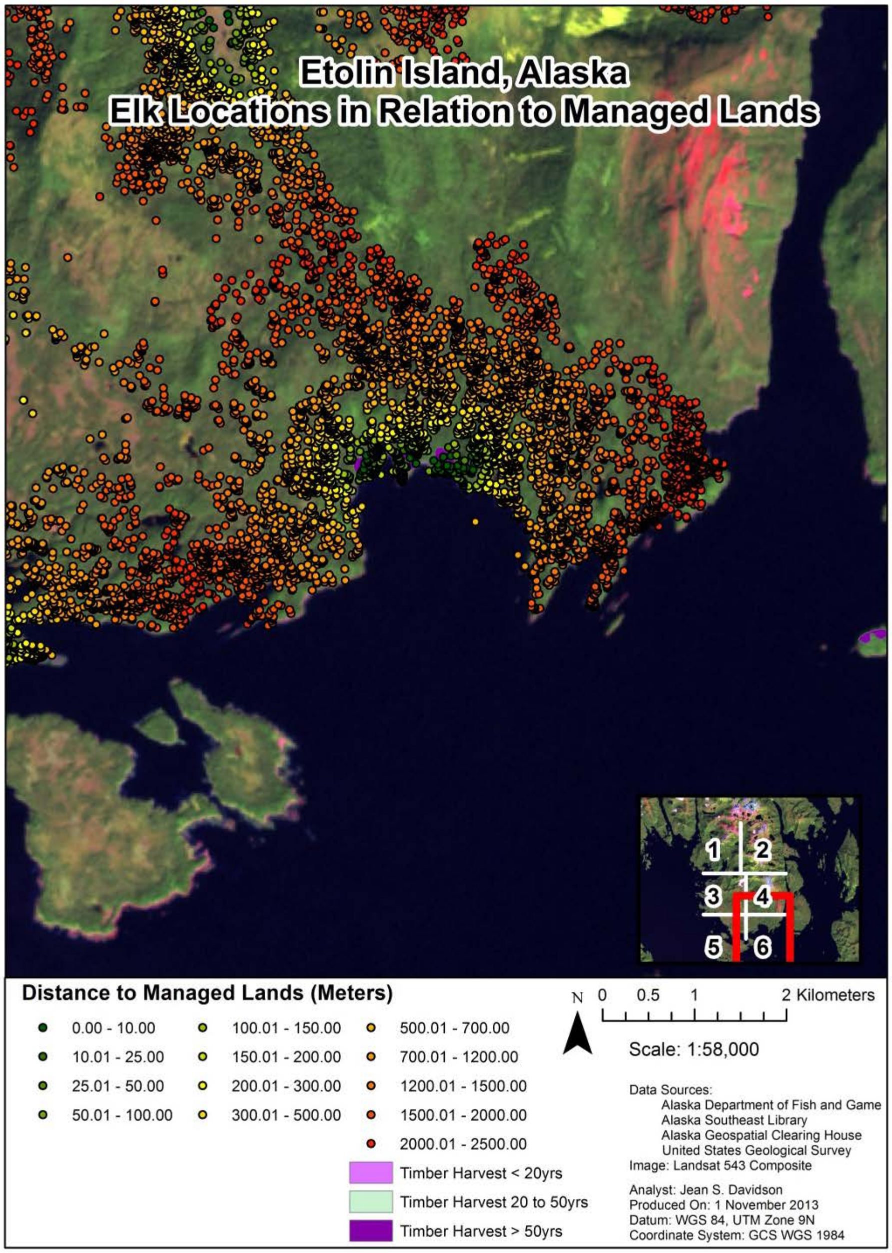

Figure 30. Etolin Island, Elk Locations in Relation to Managed Lands, Subset 6

Zarembo Island

As requested by the Alaska Department of Fish and Game, using geostatistics and analytical toolsets within the software Table 6 through Table 8 provide summaries of elk preferences on Zarembo Island. Figure 39 through Figure 53 provide visual results of the data. These tables and figures are a summation of both the day and night preferences of the elk, totaling 8,885 georeferenced points. In order to answer the preference question based upon seasonal variation, a density model was developed, figures Figure 32 through Figure 38. Due to the number of reference records each analysis area was subsetted in order to obtain data granularity. The subset areas are depicted in Figure 31.

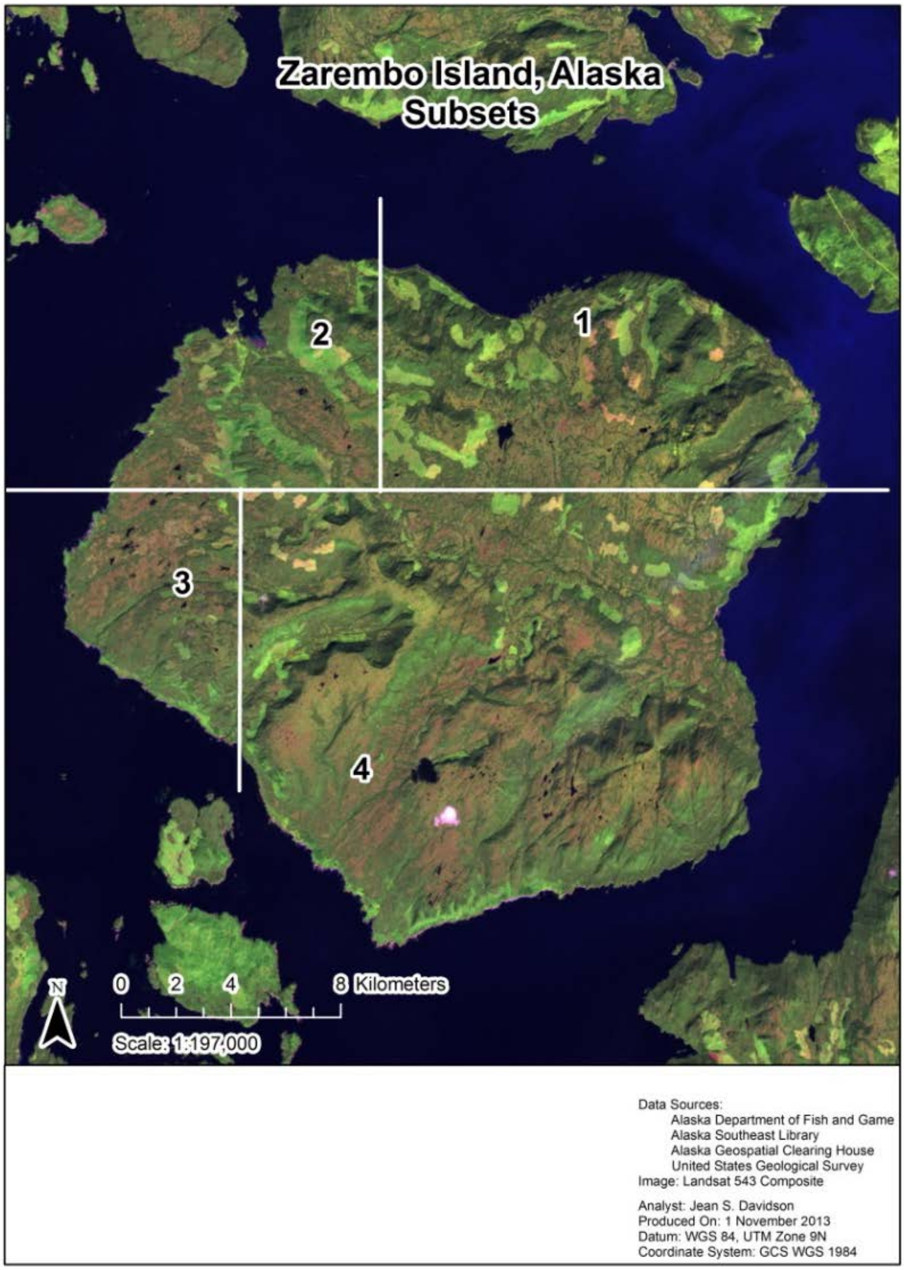

Figure 31. Zarembo Island, Subset Areas

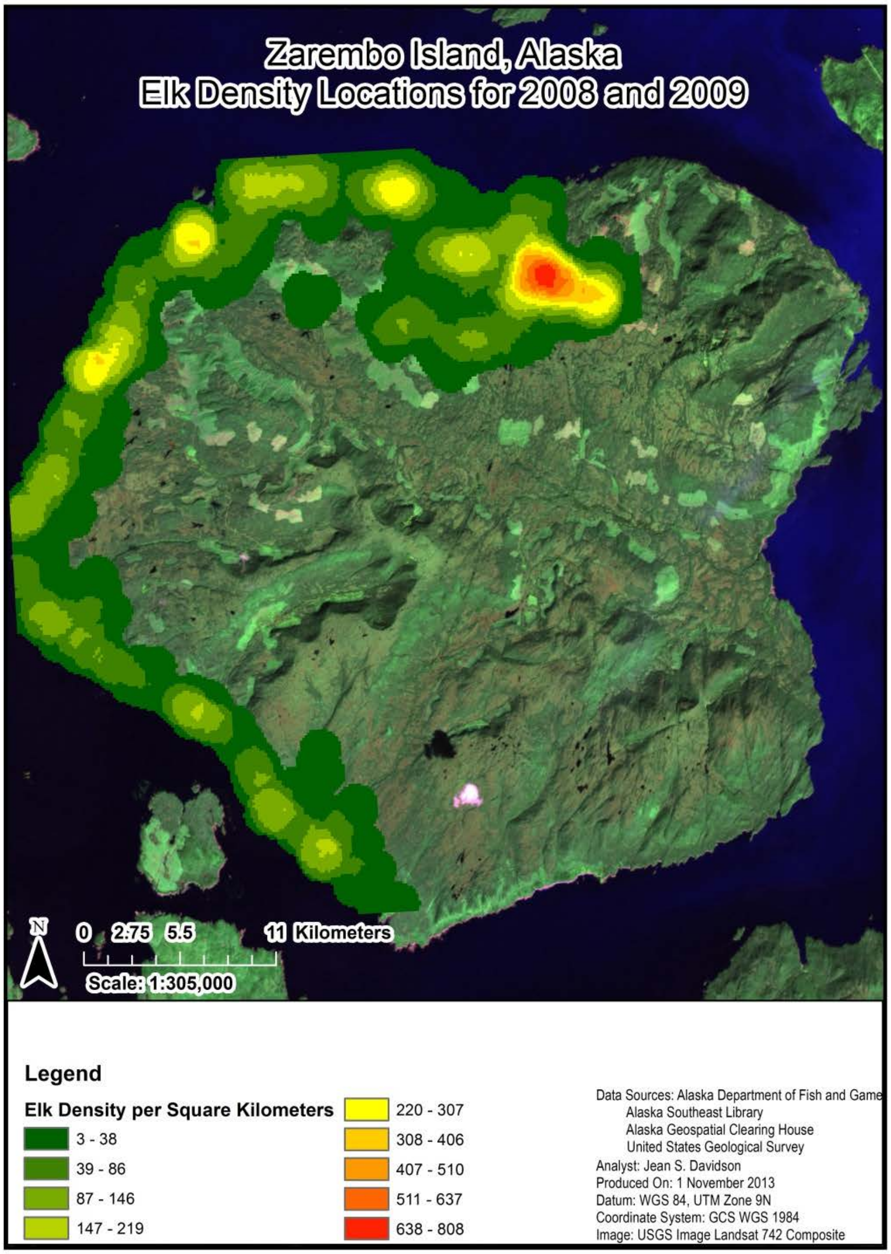

Figure 32. Zarembo Island, Elk Density Locations for 2008 and 2009

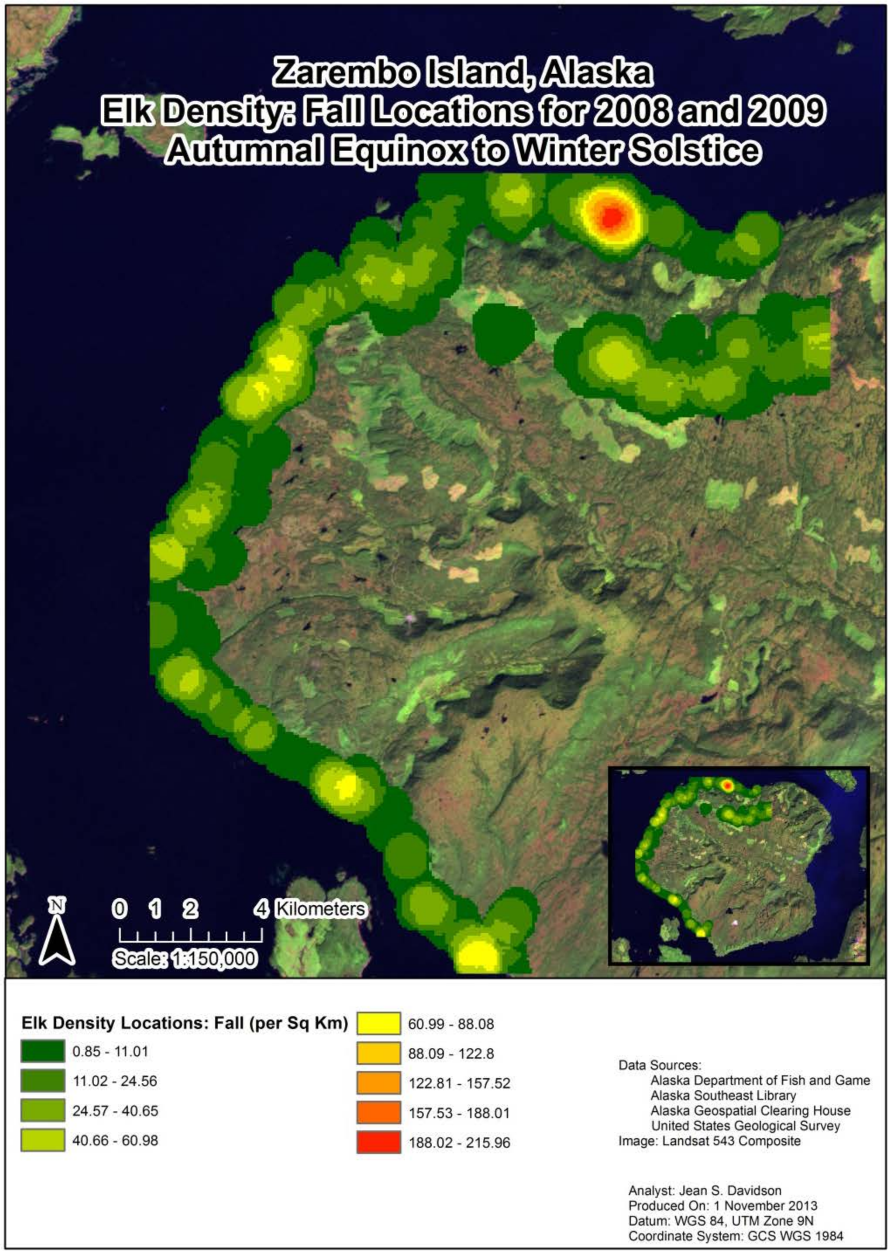

Figure 33. Zarembo Island, Elk Density Locations: Autumnal Equinox to Winter Solstice

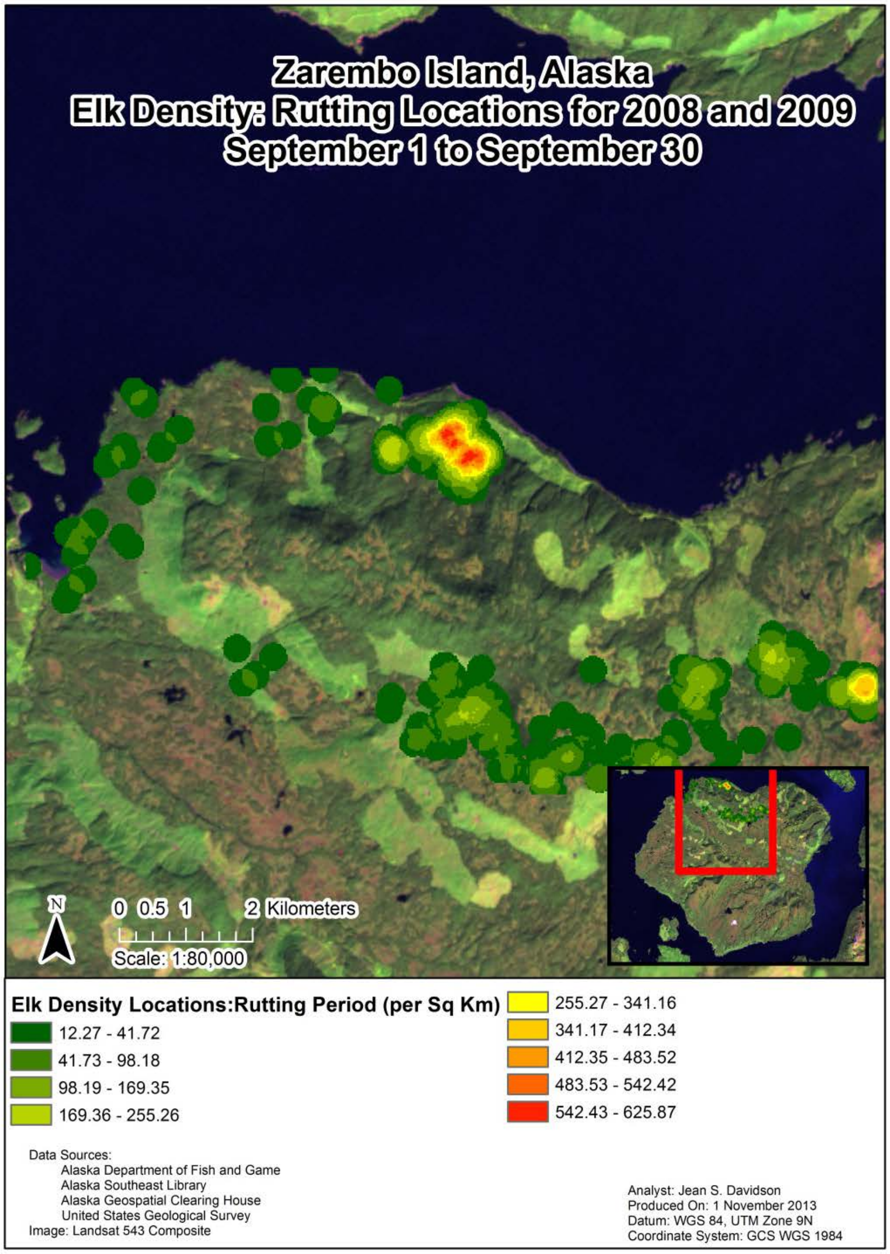

Figure 34. Zarembo Island, Elk Density Rutting Locations

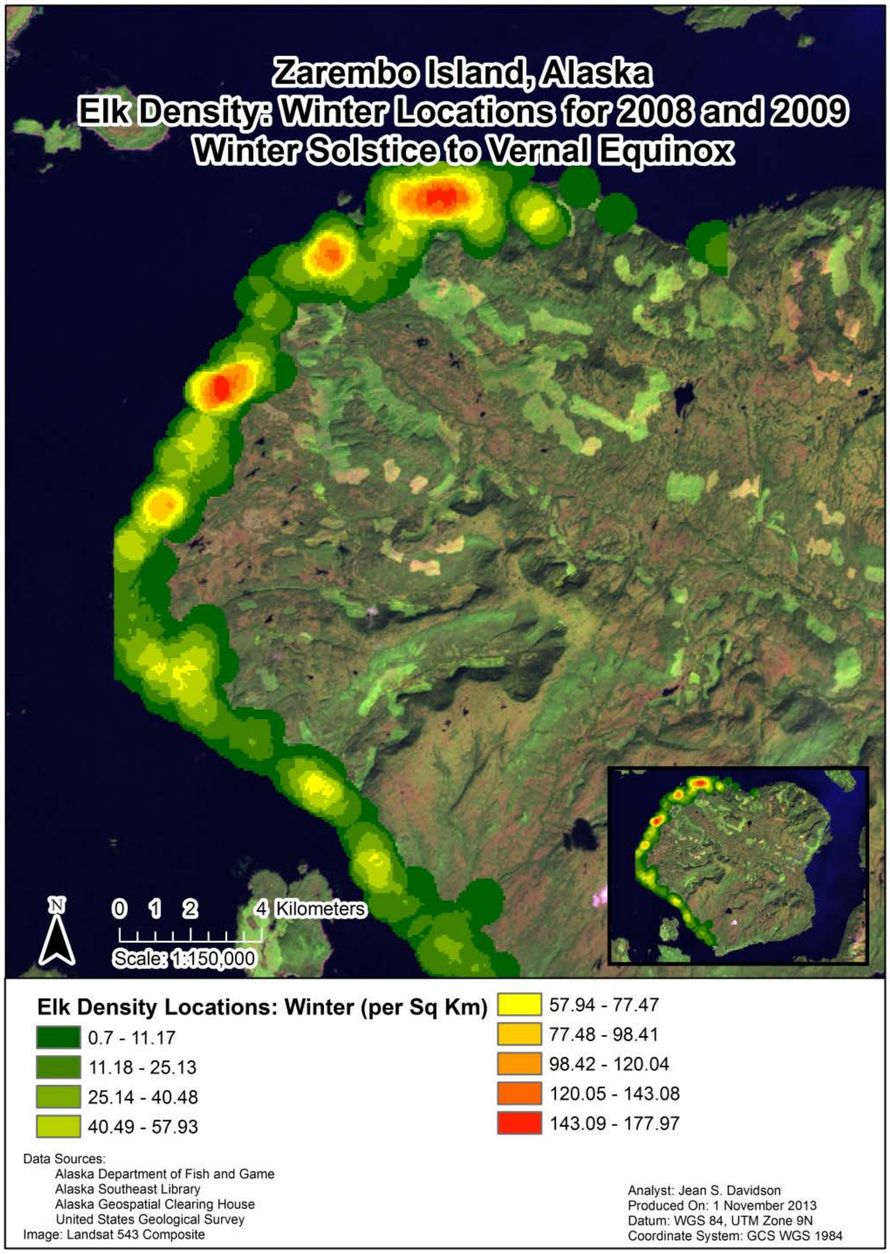

Figure 35. Zarembo Island, Elk Density Locations: Winter Solstice to Vernal Equinox

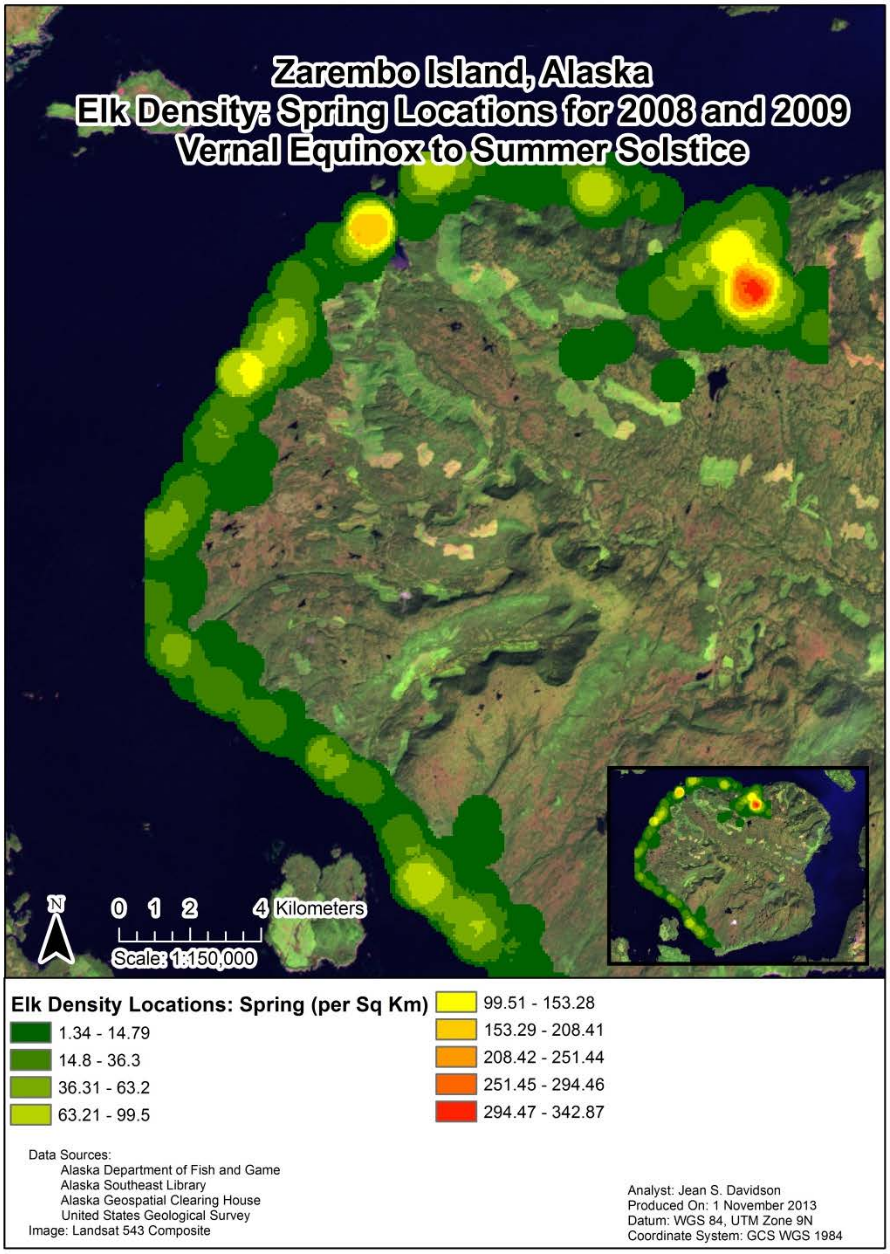

Figure 36. Zarembo Island, Elk Density Locations: Vernal Equinox to Summer Solstice

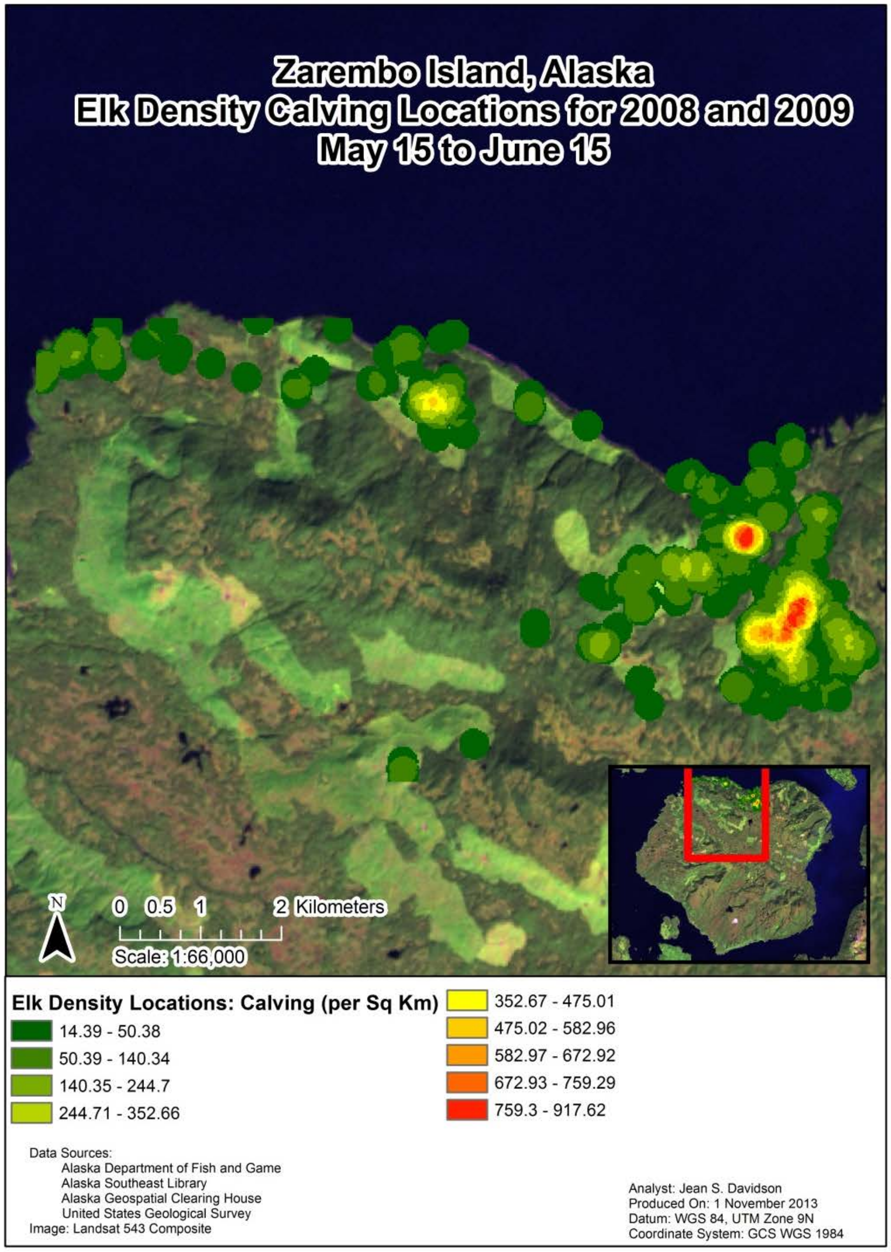

Figure 37. Zarembo Island, Elk Density Calving Locations

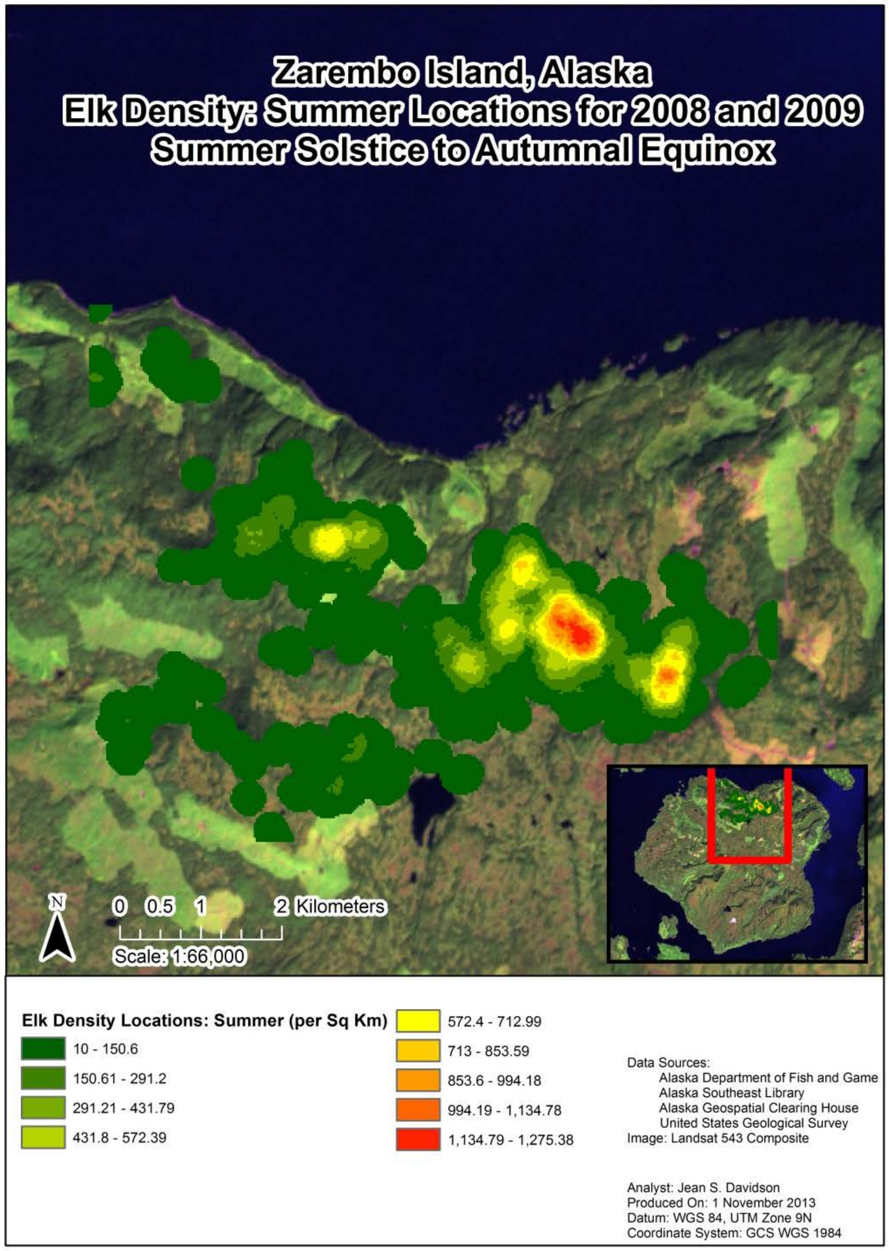

Figure 38. Zarembo Island, Elk Density Locations: Summer Solstice to Autumnal Equinox

Table 6. Zarembo Island, Elk Preference to Proximity to Streams

Proximity to Streams (in meters)

	All	Day	Night	*Calving
Number of Records	8,885	4,917	3,968	942
Minimum	0.35	0.35	0.94	0.94
Maximum	1,529.23	1,287.78	1,529.23	1,045.11
Mean	357.16	358.85	355.06	370.36
Standard Deviation	253.33	250.54	256.73	209.06

* Calving numbers include both day and night elk locations.

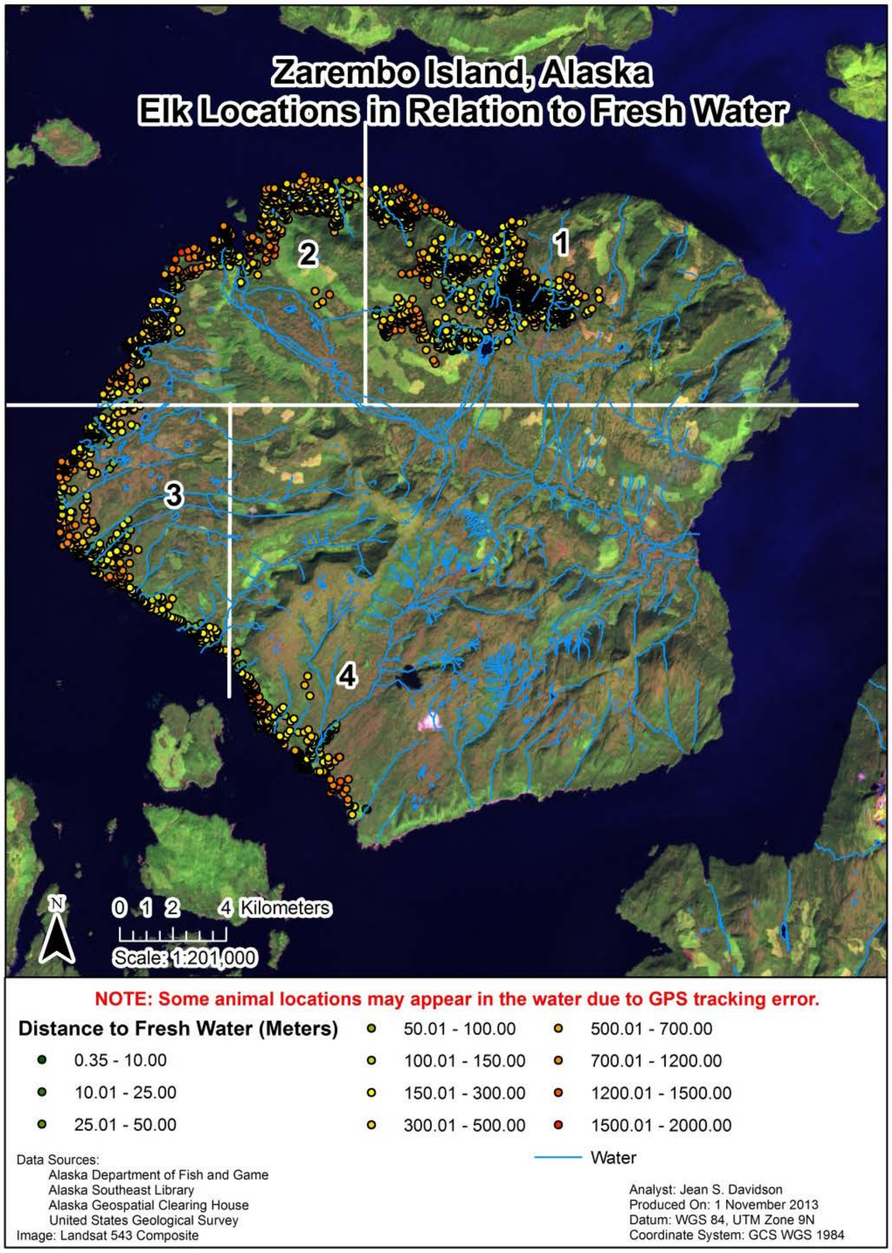

Figure 39. Zarembo Island, Elk Locations in Relation to Fresh Water

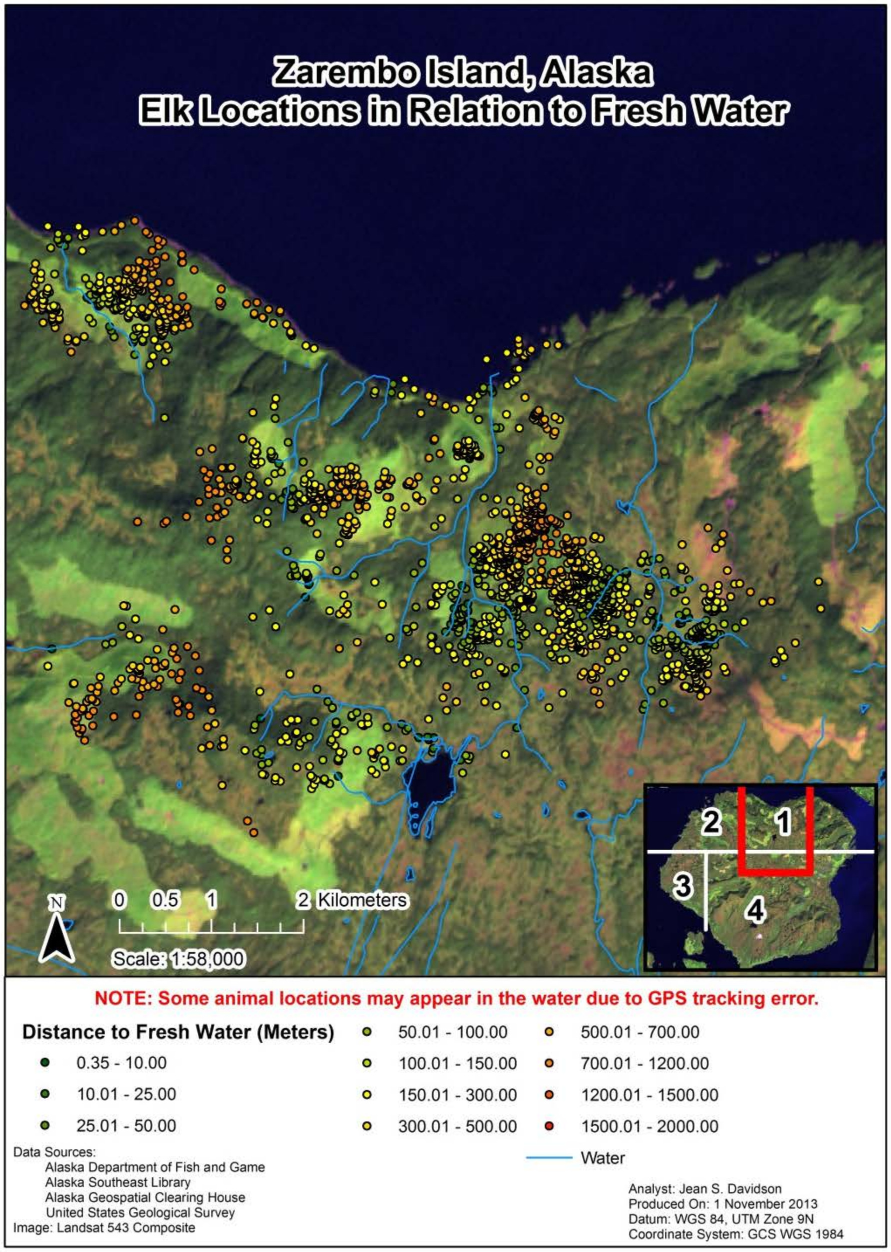

Figure 40. Zarembo Island, Elk Locations in Relation to Fresh Water, Subset 1

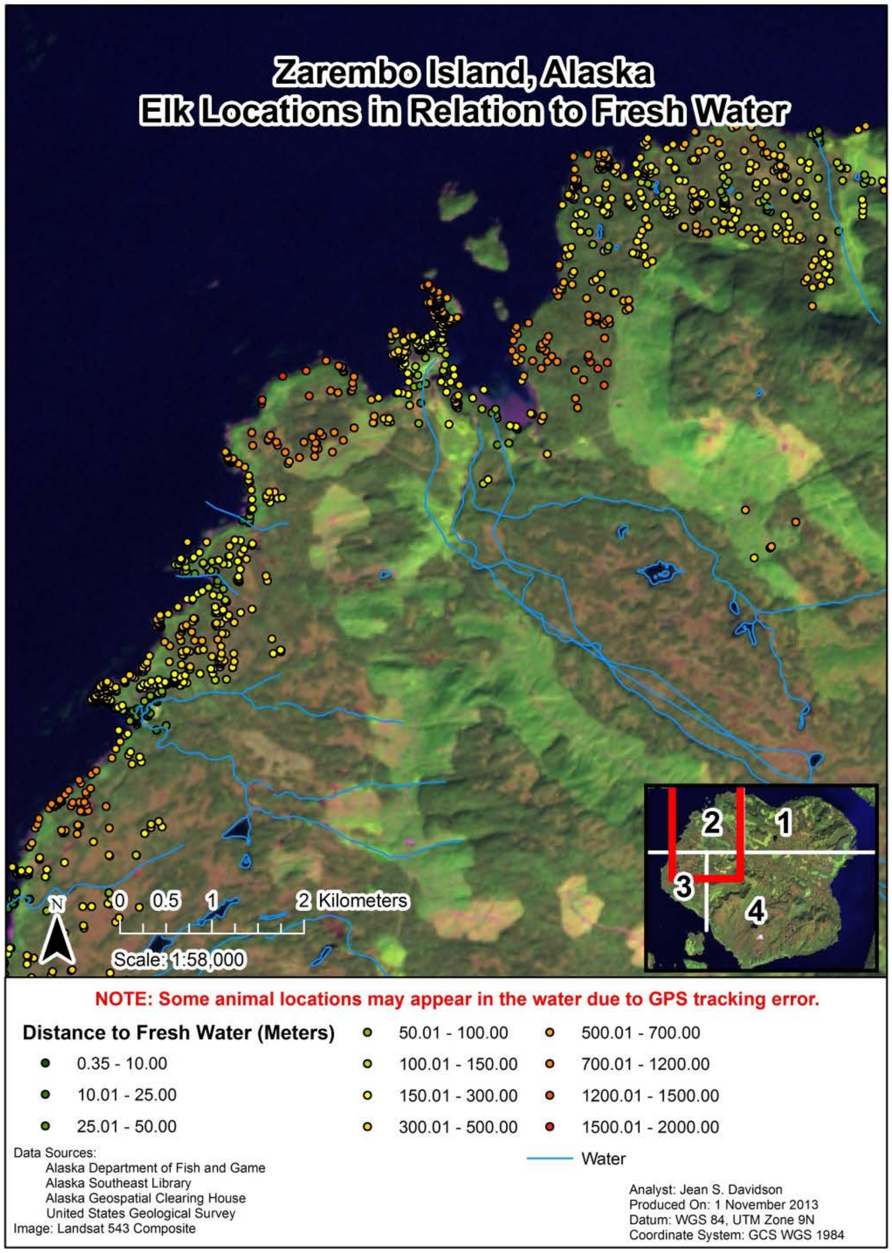

Figure 41. Zarembo Island, Elk Locations in Relation to Fresh Water, Subset 2

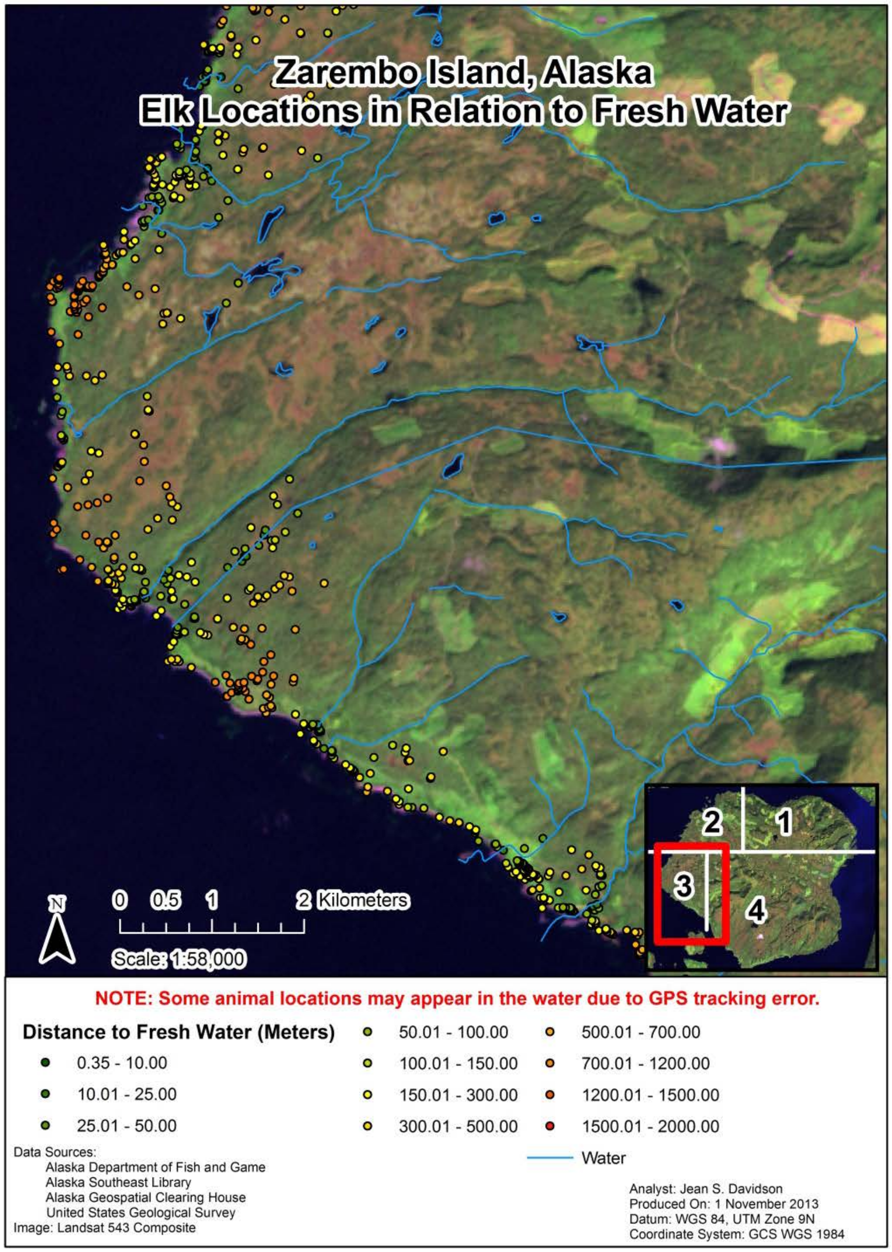

Figure 42. Zarembo Island, Elk Locations in Relation to Fresh Water, Subset 3

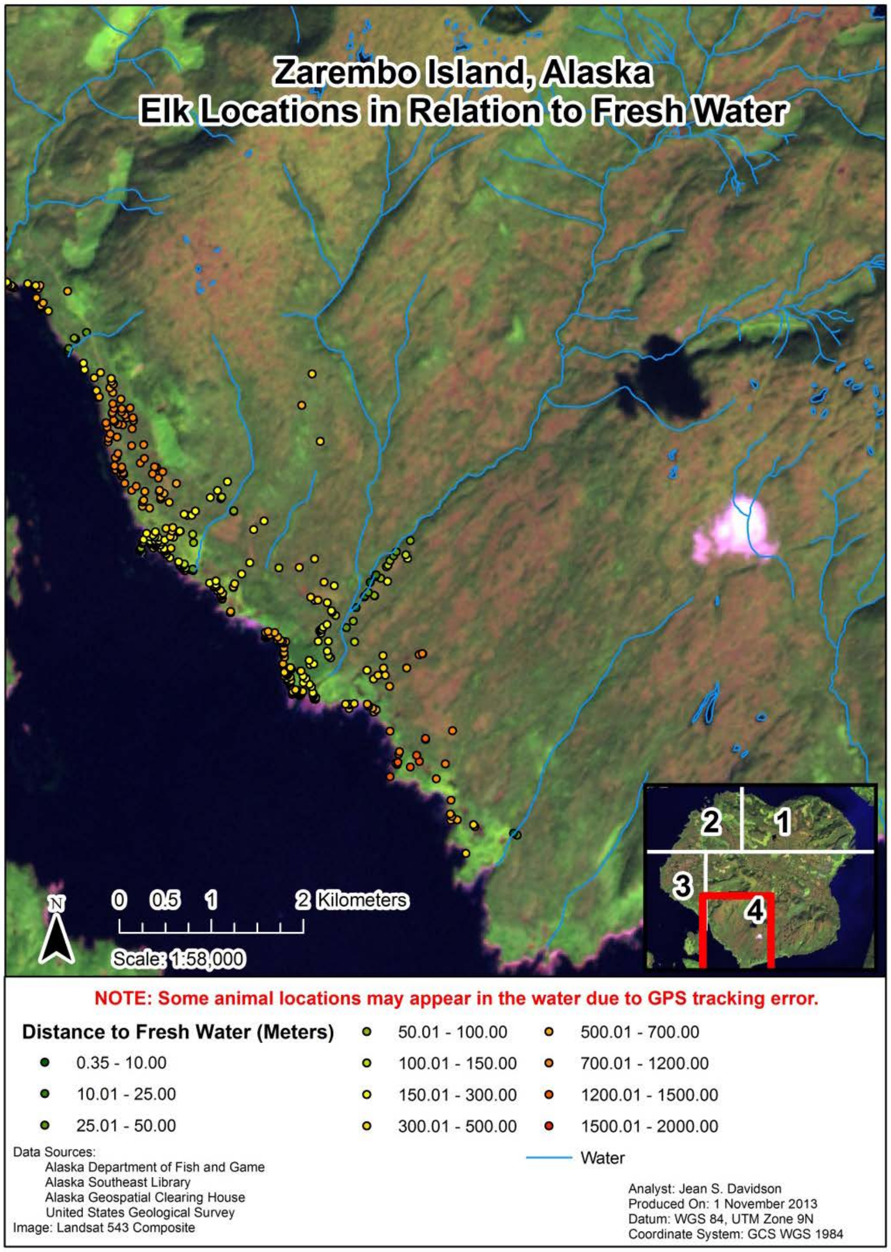

Figure 43. Zarembo Island, Elk Locations in Relation to Fresh Water, Subset 4

Table 7. Zarembo Island, Elk Preference to Slope Percentage

Elk Preference to Slope Percentage

	All	Day	Night	*Calving
Number of Records	8,885	4,917	3,968	942
Minimum	0.00	0.00	0.00	0.00
Maximum	45.00	45.00	39.00	45.00
Mean	10.28	11.15	9.21	13.26
Standard Deviation	7.71	8.00	7.18	7.39

* Calving numbers include both day and night elk locations.

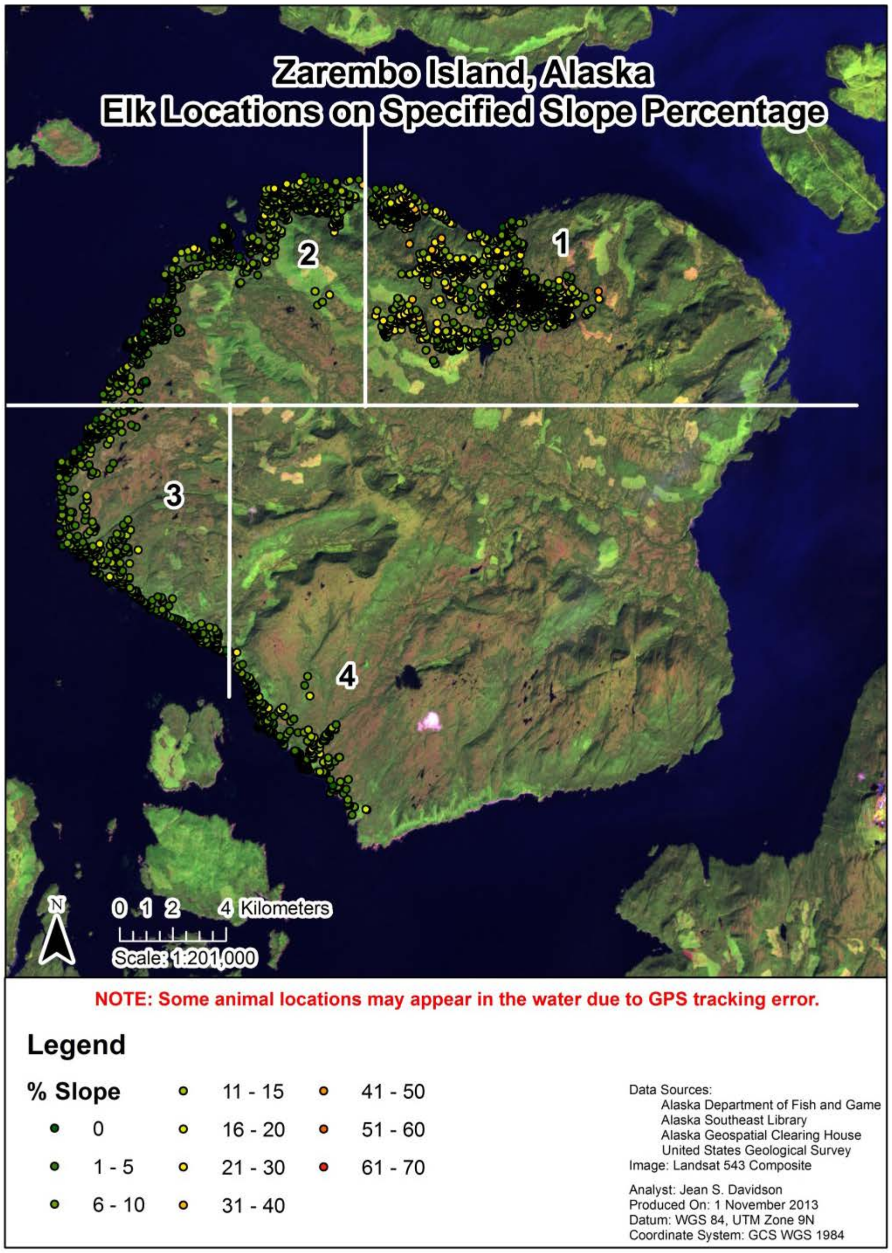

Figure 44. Zarembo Island, Elk Locations on Specified Slope Percentage

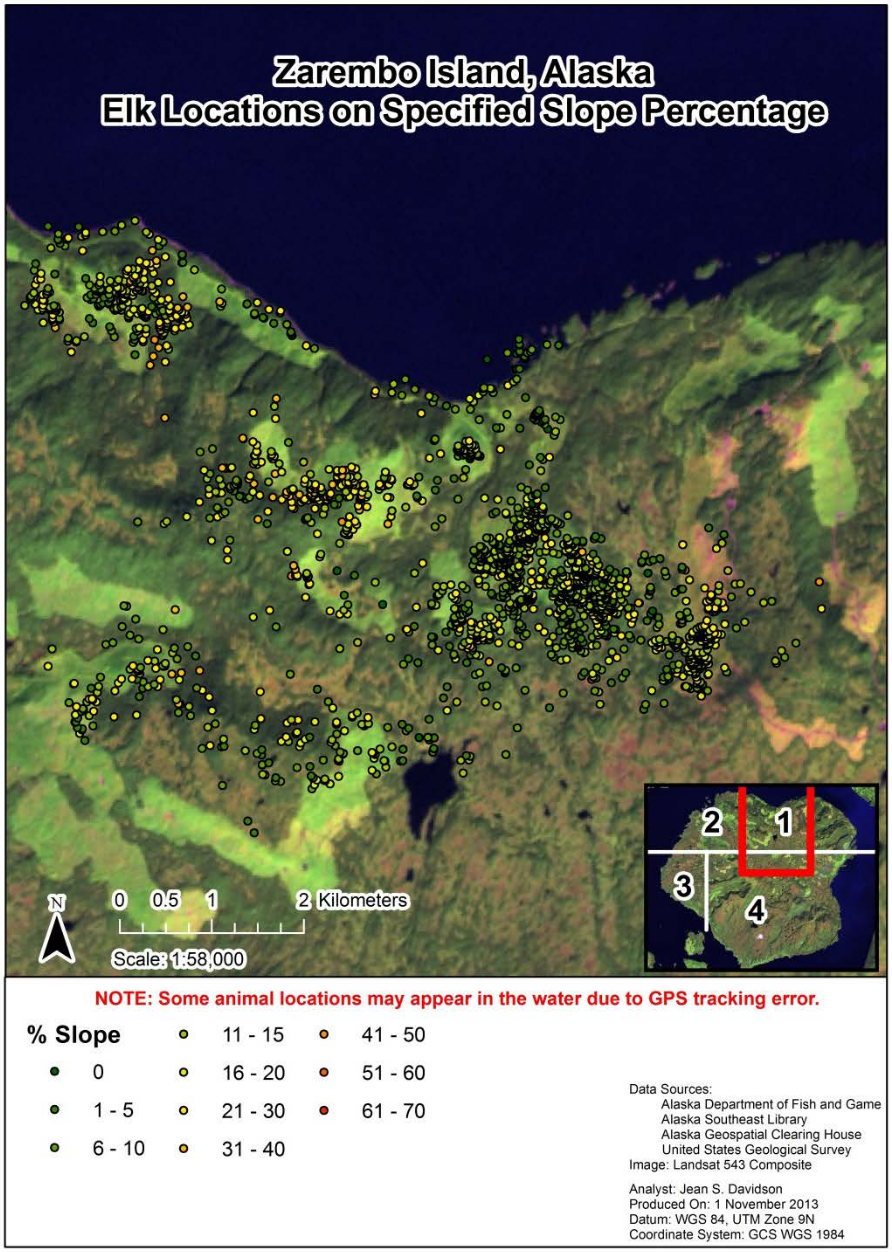

Figure 45. Zarembo Island, Elk Locations on Specified Slope Percentage, Subset 1

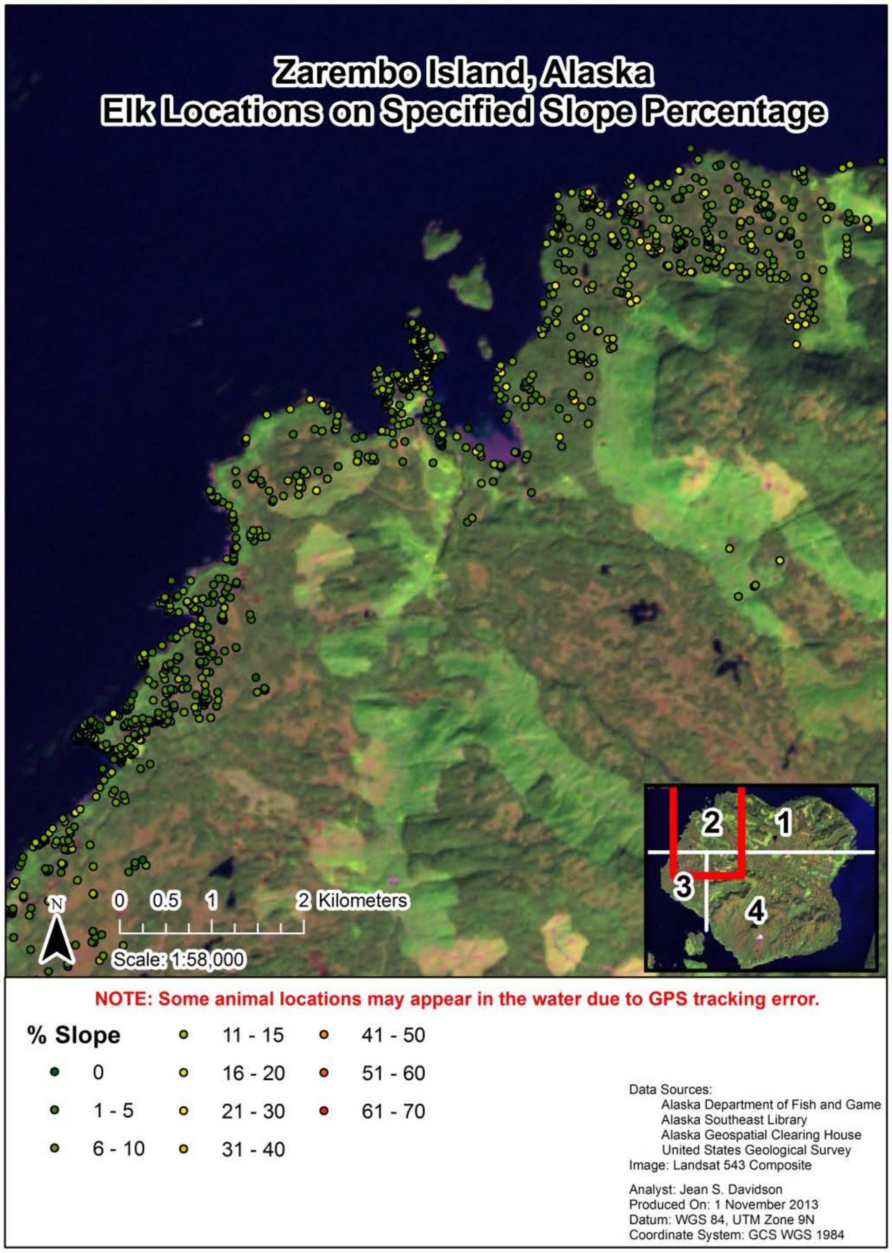

Figure 46. Zarembo Island, Elk Locations on Specified Slope Percentage, Subset 2

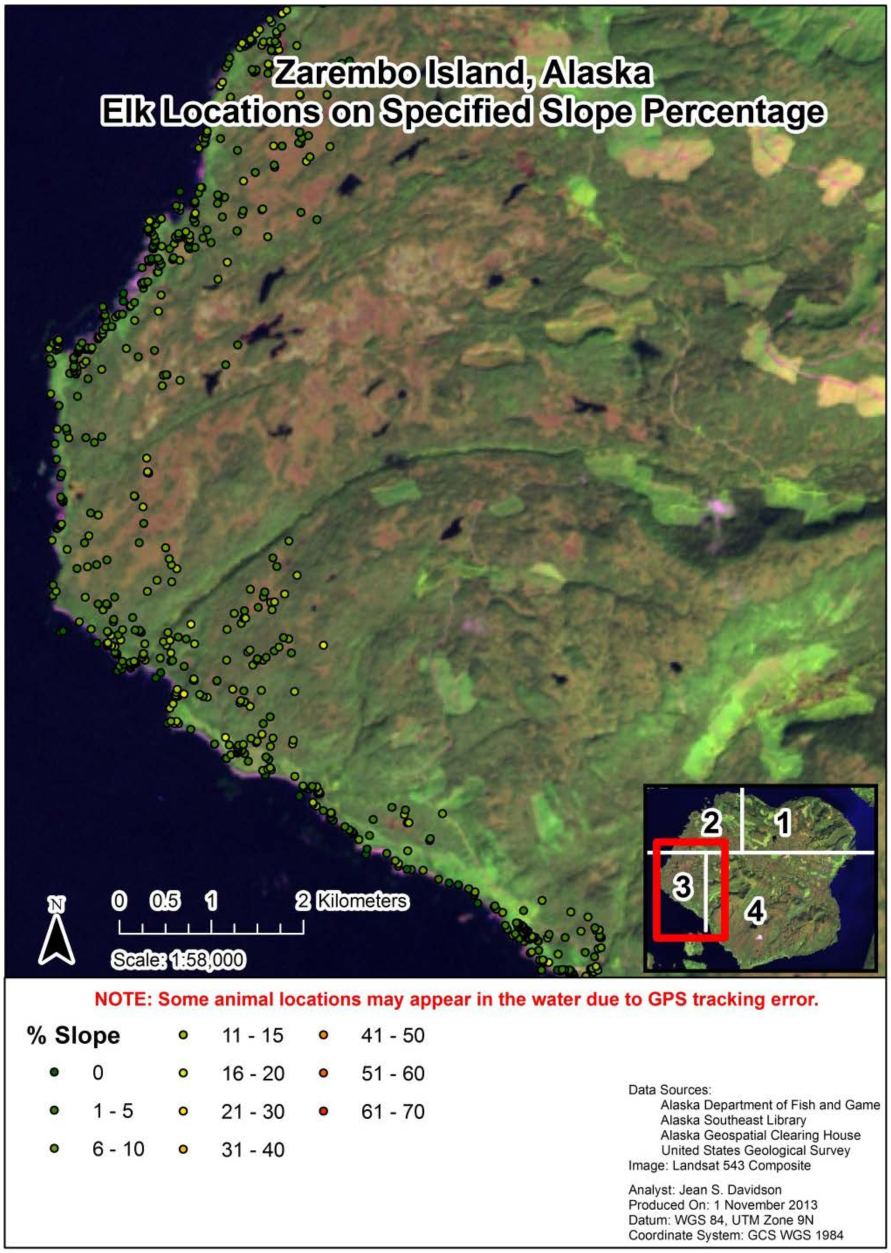

Figure 47. Zarembo Island, Elk Locations on Specified Slope Percentage, Subset 3

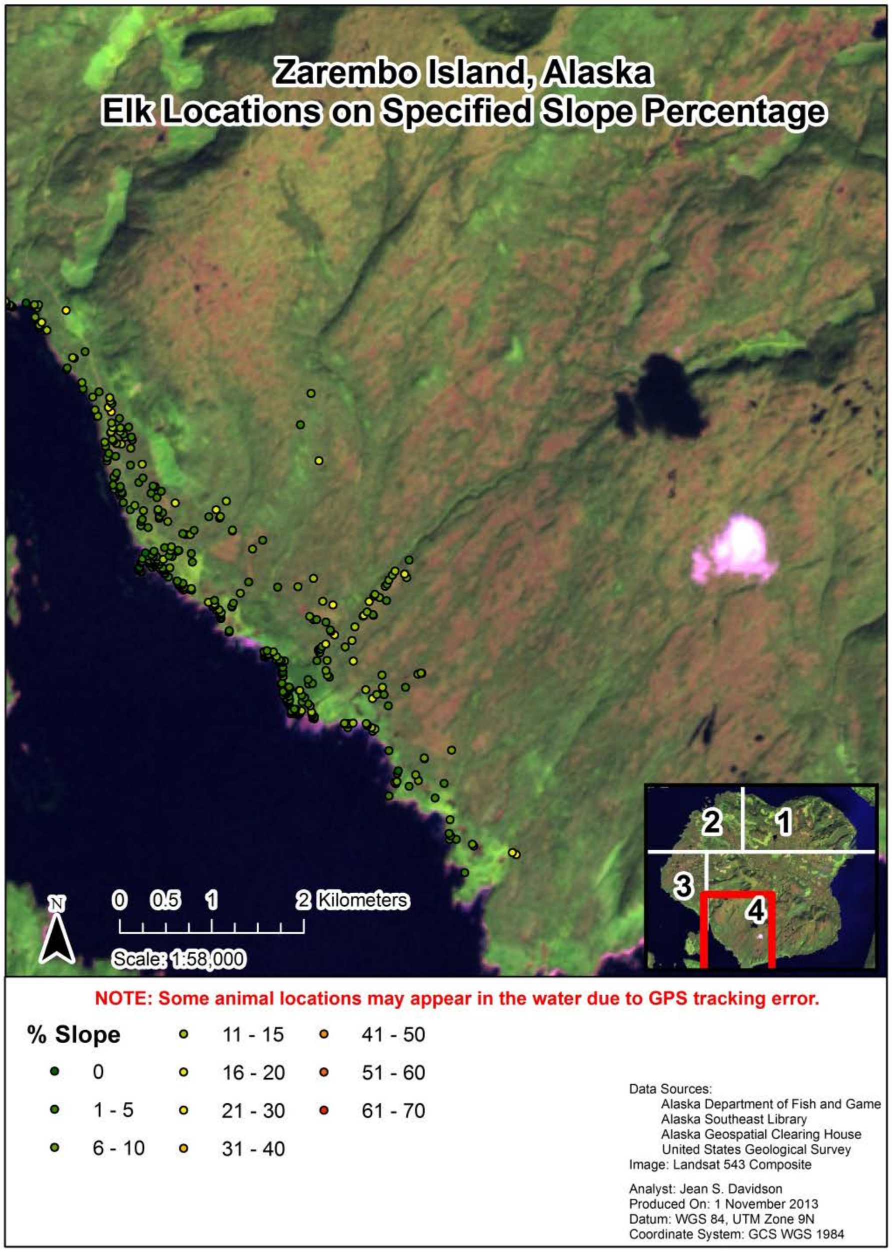

Figure 48. Zarembo Island, Elk Locations on Specified Slope Percentage, Subset 4

Table 8. Zarembo Island, Elk Preference to Managed and Unmanaged Lands

Elk Preference to Managed and Unmanaged Lands

	All		Day		Night		Calving	
	Count	%	Count	%	Count	%	Count	%
Miscellaneous/ Unknown	1,546	17.40%	426	8.66%	1,120	28.23%	36	3.82%
Forested Muskeg	668	7.52%	364	7.40%	304	7.66%	38	4.03%
Cut Age <20	88	0.99%	54	1.10%	34	0.86%	0	0.00%
Cut Age >=20 and <=50	2,943	33.12%	1,995	40.57%	948	23.89%	696	73.89%
Cut Age >50	74	0.83%	44	0.89%	30	0.76%	10	1.06%
Non-Forest	56	0.63%	14	0.28%	42	1.06%	0	0.00%
Young Growth Size 2	22	0.25%	4	0.08%	18	0.45%	2	0.21%
Young Growth Size 3	0	0.00%	0	0.00%	0	0.00%	0	0.00%
Growth Size 4 hydric	1,370	15.42%	594	12.08%	378	9.53%	72	7.64%
Growth Size 4 non-hydric	1,346	15.15%	1,042	21.19%	702	17.69%	68	7.22%
Unproductive Forest	772	8.69%	380	7.73%	392	9.88%	20	2.12%
Water	0	0.00%	0	0.00%	0	0.00%	0	0.00%

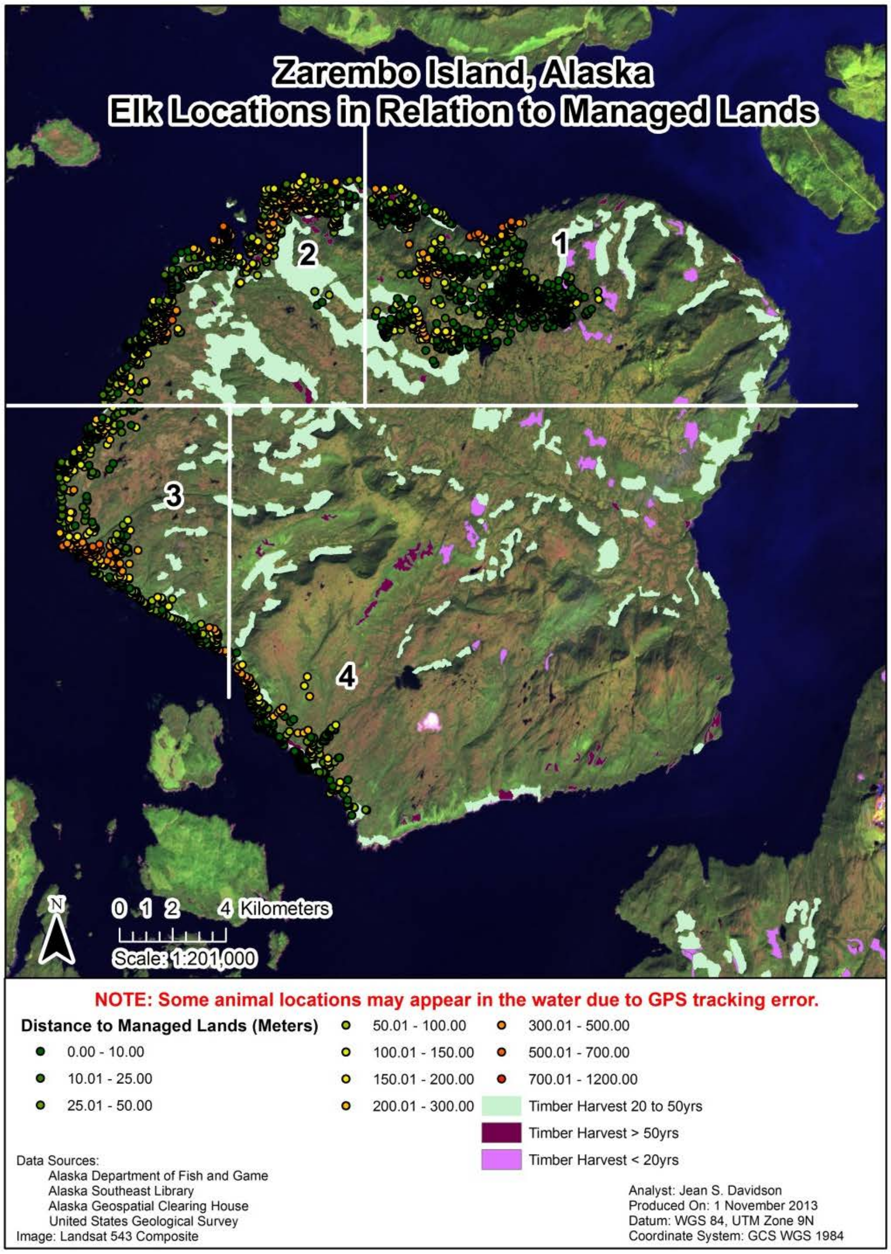

Figure 49. Zarembo Island, Elk Locations in Relation to Managed Lands

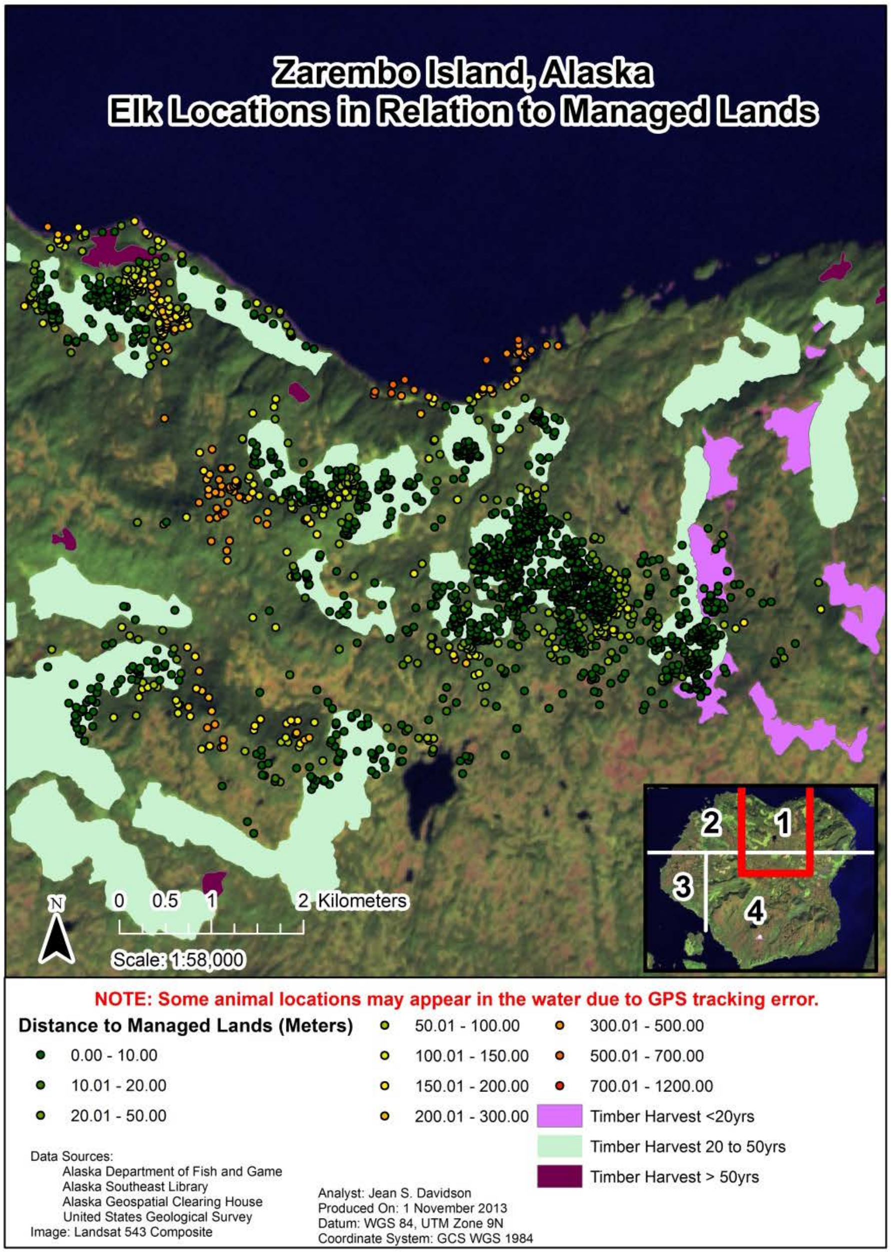

Figure 50. Zarembo Island, Elk Locations in Relation to Managed Lands, Subset 1

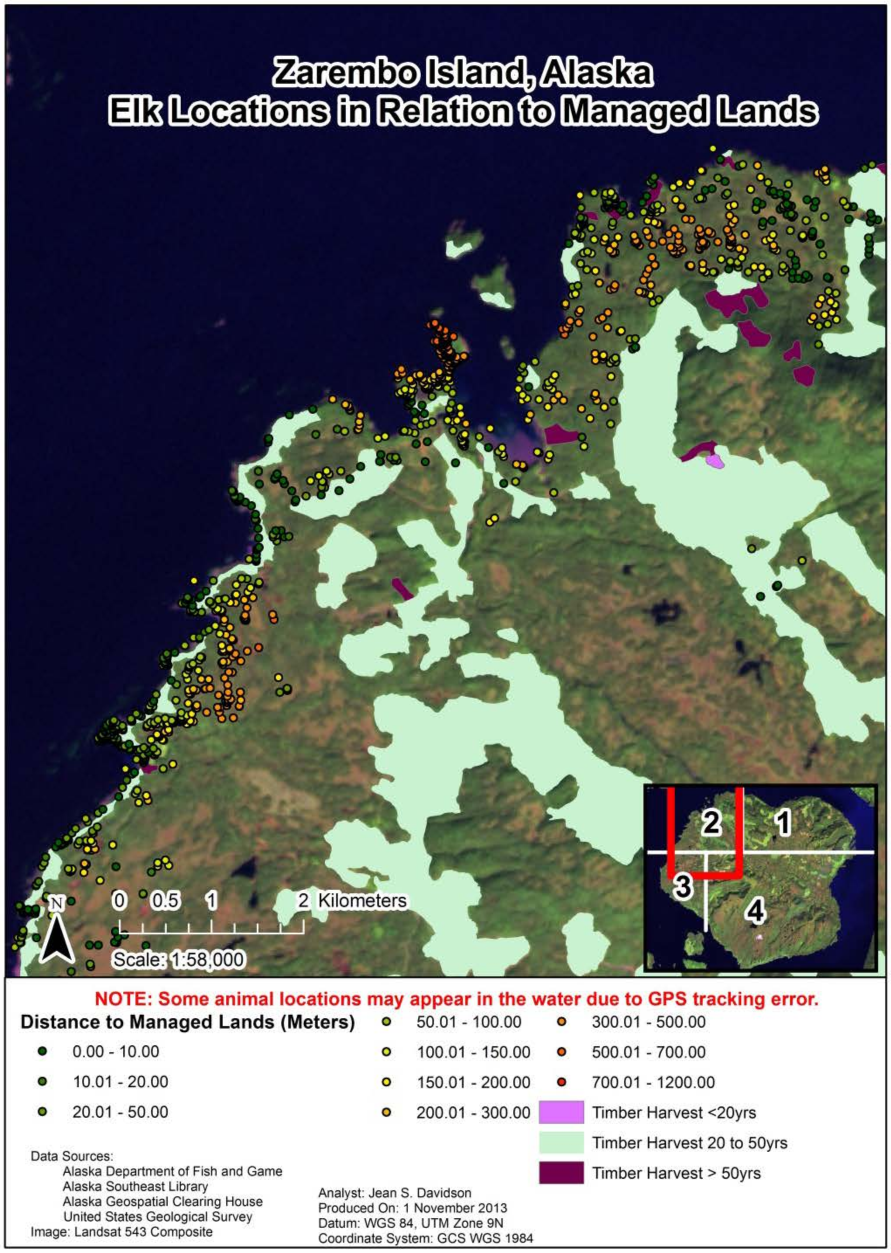

Figure 51. Zarembo Island, Elk Locations in Relation to Managed Lands, Subset 2

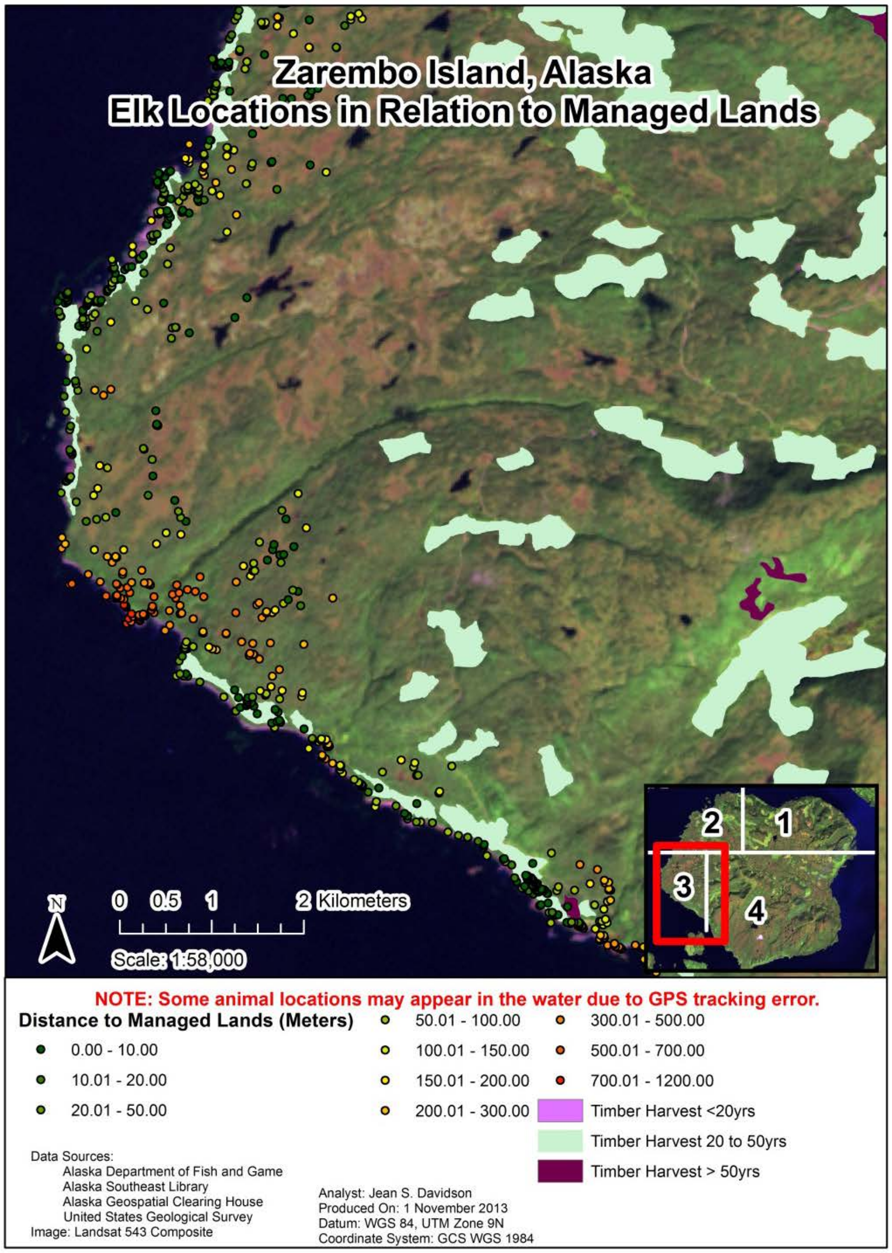

Figure 52. Zarembo Island, Elk Locations in Relation to Managed Lands, Subset 3

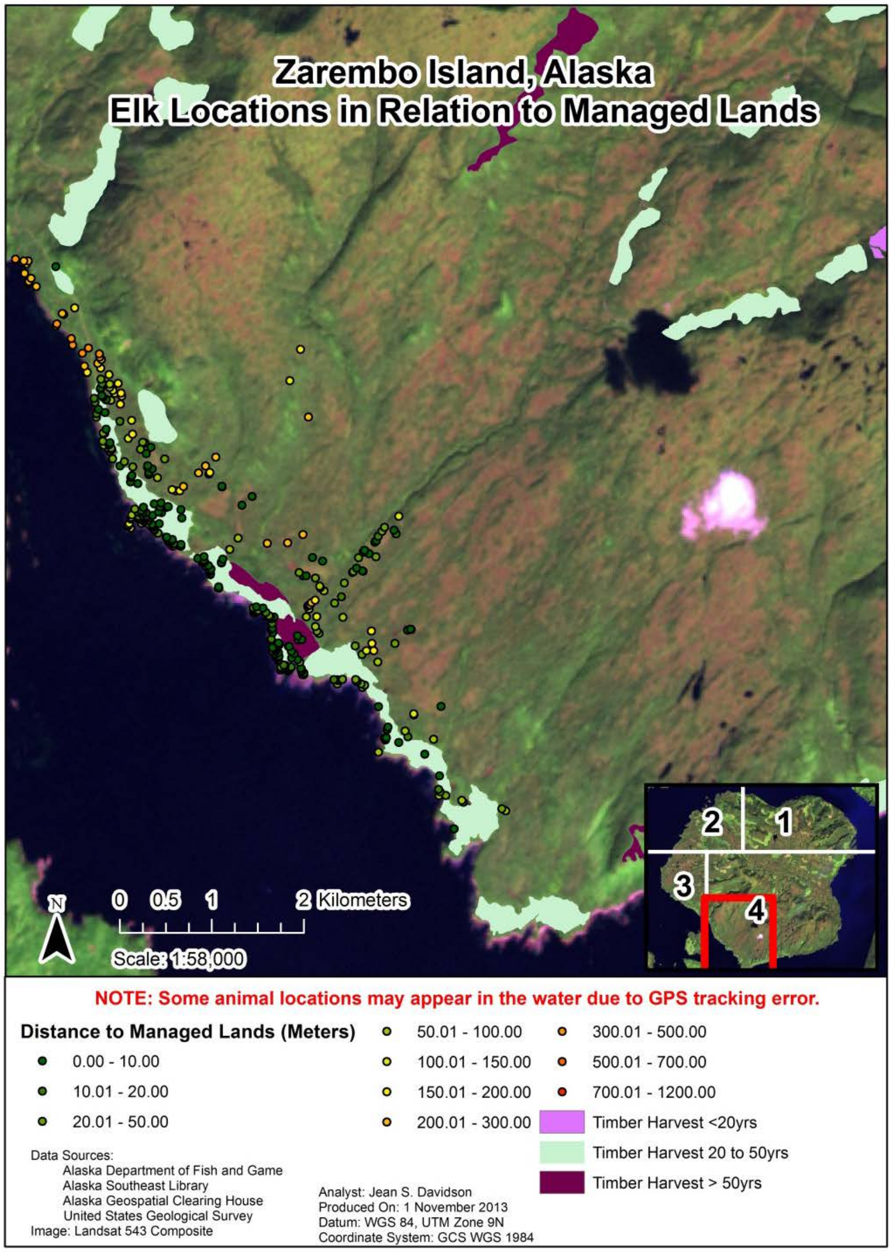

Figure 53. Zarembo Island, Elk Locations in Relation to Managed Lands, Subset 4

Chapter Four: Discussion

Density

Data displays elk prefer the southern tip of Etolin Island. Figure 3 shows the concentration of the elk over a three year time period. Although there are areas of concentration over the three years, the majority of the time, the elk appear to be dispersed throughout the southern tip. By extracting the specific dates, the elk show different areas of concentration. The data shown in Figure 4 through Figure 9 displays the areas in which the elk tend to prefer, to include specific calving and rutting areas. According to Schwartz and Mitchell (1945), elk have a tendency to return to selected calving areas.

In contrast to the Etolin Island elk, the elk found on Zarembo Island are not moving from the southern tip in a direct northerly fashion. Rather the Zarembo elk have a preference to move along the western coastline to the central northern section (Figure 32 through Figure 38). Another difference, is the Zarembo Island elk have smaller concentrated areas for each season, to include rutting and calving areas. The density figures are smaller due to the limited number of records; however the information obtained shows that the Zarembo Island elk prefer the coastline compared to inland valleys.

Fresh Water

The proximity to fresh water is one of the main habitat factors for elk (Bowyer, 1981; Schwartz, II & Mitchell, 1945; Bettinger, Boston, & Sessions, 1998; Kneib, Knauer, & Kuchenhoff, 2009; Niederleitner, 1987; Gates and Hudson, 1981; Skovlin, 1982). Understanding the preference of elk to fresh water sources will assist biologist and managers to develop comprehensive management plans. The distance of the elk to fresh water sources range from 0.006 meters to 2,066.7 meters. These figures do not include the fresh water from the rainfall pooling in the muskeg. The available data does not provide this level of detail; however the Dictionary.com (2013) definition of muskeg is, “a bog of northern North America, commonly having sphagnum mosses, sedge, and sometimes stunted black spruce and tamarack trees”. Since muskeg, by definition, contains many areas of water, it can be reasonably expected that elk may use these areas for sources of water. Table 3 displays the results of the availably of fresh water to the Etolin elk. The findings on Etolin Island do not support the concept that elk prefer smaller distances to larger distance from fresh water. Figure 10 through Figure 16 displays the location of the elk in relation to sources of fresh water sources. Rain water pooled in the clear cuts and muskeg are not included in this analysis due to the limited environmental and topological data available.

Similar to the Etolin elk, the Zarembo elk has a large variation between location and the proximity of fresh water. The range of the 8,885 records is 0.35 meters to 1,529.23 meters, with a standard deviation of 209.06 meters to 253.33 meters (Table 6). Figure 39 through Figure 43 depict the Zarembo elk locations in proximity to fresh water. Rain water pooled in the clear cuts and muskeg are not included in this analysis due to the limited environmental and topological data available.

Slope

Frair, Merrill, Visscher, Fortin, Beyer, & Morales (2005) found that elk preferred moderately steep slopes for foraging. The elk on Etolin Island support this theory. Findings indicate the Etolin elk have a slope mean 13.04 percent (Table 4). The slope preference changes depending on the day or night variance as well as the calving season. The Etolin elk prefer a moderate to steep slope of 16.89 percent. The maximum slope percentage for the Etolin elk is 69 percent.

In contrast to the Etolin Island elk, the Zarembo Island elk do not prefer moderately steep slopes. The mean slope for all periods is 11.15 percent (Table 7). This is 1.89 percent less than Etolin Island for the overall mean. The day and night averages has a slope of 9.21 percent. The Zarembo Island calving area has a significantly higher slope, 13.26 percent.

The maximum slope the Zarembo Island can be found was 45 percent compared to the 69 percent on Etolin Island. Figure 44 through Figure 48 display the elk locations in relation to the percentage of slope.

Managed Lands

According to Bettinger, Boston, and Sessions (1998) elk use forage as a means of thermal cover. Data from the Etolin Island elk support this theory. The Etolin Island elk prefer thermal coverage from the unproductive forest category in comparison to managed lands during night time hours. This trend continues for the day hours as well as the calving season. These figures indicate that the elk do not prefer the managed lands as the percentage ranges from 0 to 0.44 percent of usage based upon intersecting the times and timber harvested areas. Figure 49 through Figure 53 provide the visual representation of elk locations in relation to the managed lands on Etolin Island.

Elk found on Zarembo Island have a different preference compared to those elk found on Etolin Island. The elk on Zarembo Island display a preference for managed lands, especially harvested areas that are 20 to 50 years old (Table 8). During calving season, there was a 74.89 percent that elk would be located on harvested lands. The findings also indicate the elk do not use the surrounding forest areas for thermal cover. However, there are a significant percentage of unknown areas that may skew the results.

Chapter Five: Summary

Based upon the findings between the elk on Etolin and Zarembo Islands, there appears to be significant preference differences. The differences also counter other elk studies (Bowyer, 1981; Schwartz, II & Mitchell, 1945; Bettinger, Boston, & Sessions, 1998; Kneib, Knauer, & Kuchenhoff, 2009; Niederleitner, 1987; Gates & Hudson, 1981; Skovlin, 1982; Frair, Merrill, Visscher, Fortin, Beyer, & Morales, 2005). Due to these significant differences, it is strongly recommended to conduct further analysis on the transplanted elk by considering the following topics:

- Determine species of elk on each island
- Determine if elk use fresh water in muskeg

By determining the dominant species of elk on each island, specific characteristics may be obtained. Although the Roosevelt Elk and the Rocky Mountain Elk have similar overall characteristics, they may vary slightly in their habitat preferences. These minor differences may account for the differences in slope and their routes toward the northward on each island. The data obtained during the course of this project will be able to provide wildlife biologists and forest management personnel with baseline information for drafting a long term management plan for Southeast Alaska.

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